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PROGRESS REPORT

on

HORTICULTURAL CROPS RESEARCH

of the

UNITED STATES DEPARTMENT OF AGRICULTURE

U. S. DEPT. OF AGRICULTURE
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APR 22 1969

CURRENT SERIAL RECORDS

This progress report includes a summary of the current research of the USDA on horticultural crops and a preliminary report of progress made during the preceding year. It is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of progress on USDA and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of USDA and cooperative research issued between July 1, 1967, and June 30, 1968. Current agricultural research findings are also published in the monthly USDA publications, Agricultural Research and The Farm Index.

RESEARCH PROGRAM DEVELOPMENT AND EVALUATION STAFF
UNITED STATES DEPARTMENT OF AGRICULTURE

WASHINGTON, D.C.

December 31, 1968

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II. NUTRITION, CONSUMER AND INDUSTRIAL USE RESEARCH

NUTRITION AND CONSUMER-USE RESEARCH

Consumer and Food Economics Research Division, ARS

Human Nutrition Research Division, ARS

USDA and Cooperative Program

Location of Intramural Work	Scientist Man-Years F.Y. 1968				
	Research Problem Area				Total
	701	703	704	708	
Maryland	:	:	:	:	:
Beltsville	: 3.6	:	: 2.0	:	: 5.6
Hyattsville	:	: 3.4	:	: 2.2	: 5.6
Total	: 3.6	: 3.4	: 2.0	: 2.2	: 11.2

Intramural program is not supplemented by extramural support in these areas.

Problems and Objectives

Nationwide attention is focused on the need to improve the nutritional levels of some individuals and some population groups. Nutrition education and food distribution programs are being intensified and expanded. To facilitate these programs, research must continue to add to our understanding of the nutritive values of foods, the nutritional needs of people, and how their needs can best be met by food. More effective ways must be found to inform people about foods and nutrition and to help them improve their food habits. For families and institutions, new methods of handling and preparing the continuous array of new food products must be developed so that their nutritive and other desirable qualities are retained. A continuous flow of information gained from research on food consumption and dietary levels of the population, the food management practices of families, and the factors that affect their food choices is an essential research backstop to the development and evaluation of agricultural policies and programs in food and nutrition.

Major objectives of the research are:

1. To determine human requirements for nutrients and foods
2. To assess the nutritive values in foods and develop representative values
3. To evaluate food consumption patterns, dietary levels, food habits and food management practices of families and individuals
4. To develop and improve the procedures used by consumers to prepare and handle food so as to preserve or enhance its qualities
5. To review and interpret research findings on foods and nutrition for application to action programs and to develop guidance materials

Progress - USDA and Cooperative Programs

RPA 308 - HUMAN NUTRITIONAL WELL-BEING

A. Tables of Food Composition

1. Amino acid content of fruits and vegetables. Bananas and 52 varieties of fruits and vegetables that are produced in the United States are being analyzed by a contractor for the 18 amino acids commonly present in foods. The data are needed to supplement the very limited data now available on fruits and vegetables on the American market.

2. B-vitamins in foods. A recently completed survey of the literature on B-vitamins in foods showed that the absolute values reported by different authors for the pyridoxol, pyridoxal, and pyridoxamine content of a specific food often differ markedly but agree quite well on the relative proportion of the three forms. Processing and storage alter the relative proportions as well as the absolute content of these three free forms of vitamin B₆. The survey also showed that research is needed to determine the biological activity of these three forms of the vitamin, as well as the effects of processing and storage on the proportions of them in many more plant and animal products.

B. Nutritive Value of Meals as Served

Type A school lunch. Twenty lunch composites obtained in the fall of 1966 from each of 300 schools located in 19 states and five geographic regions were analyzed for seven vitamins. The lunches were identical with those served to sixth graders. On the average, the lunches exceeded the nutritional goal of one-third of the 1968 NRC Recommended Dietary Allowance for 10 to 12 year olds for vitamin A, riboflavin, niacin, vitamin B₁₂ and vitamin D. The average B₆ content equalled the nutritional goal. Riboflavin, which is safeguarded by the milk requirement of the Type A pattern, exceeded the goal at all schools.

Meals served in some of the schools provided substantially less of some vitamins than is desirable. Vitamin A, vitamin B₆, thiamine and vitamin D were the nutrients most often short in lunches which failed to meet the nutritional goals. For more than half of the schools, lunches failed to meet the goal for one or more of these four vitamins. Only a small proportion of the schools served lunches that furnished less than one-fourth the daily recommended allowance for one or more vitamins. Except for this small proportion, the schools served lunches that could be considered reasonably satisfactory in vitamin content.

C. Nutrition Guidelines for Food Programs

Procedures for estimating the cost of food at home for the USDA food plans were revised to reflect changes in buying patterns that occurred between the 1955 and 1965 food consumption surveys. Use of the revised procedure increased the estimated costs of the low-cost and liberal food plans by 4 percent and of the economy plan by 8 percent. It resulted in no change in the estimated cost of the moderate-cost plan.

Expenditures of about 4,000 urban households surveyed in spring 1965 were compared with costs of the USDA plans at spring 1965 prices. Roughly 13 percent of the households used food valued at less than the cost of the economy plan. Twenty-five percent used food valued at less than the cost of the low-cost plan. Forty-five percent used food valued at less

than the moderate-cost plan. Sixty-five percent used food valued at less than the liberal plan.

Nutrition research findings continue to be studied and interpreted for application to problems in food selection and food use. Special attention is given to providing support for action programs of the Department and of other government agencies. For example, the set of commodities made available to participants under the Direct Food Distribution Program was evaluated for nutritional adequacy. Also evaluated were alternative methods for improving the nutritional adequacy of the distributed commodities. These included recombination of the commodities, fortification of the commodities and the addition of new commodities. Menus using distributed commodities and based on the economy food plan are being developed for the use of leaders who work with families.

Technical assistance was given to the School Lunch Division of C&MS in the development of (1) a breakfast menu planning guide for use with the pilot school breakfast program and (2) meal patterns including minimum quantities of foods to serve, for use in special food service programs for children. An evaluation of the Type A Lunch Pattern is now being prepared using data obtained in the study of the composition of a week's lunches in 300 schools and taking into account the recently revised NRC Recommended Dietary Allowances.

RPA 704 - HOME AND COMMERCIAL PREPARATION OF FOOD

A. Food Use

1. Low-income families. Recipes for a broad range of commodities, including fruits, vegetables, rolled oats, cheese, nonfat dry milk, instant mashed potatoes, dry scrambled egg mix, and canned chicken were developed for use by low-income families participating in USDA food distribution programs. A pilot survey in two low-income housing developments in Washington, D.C. showed these recipes to be useful and acceptable.

2. National school lunch program. About 170 recipes were developed or reevaluated for the School Lunch Program. The recipes covered a wide range of commodities, including canned chopped meat, sweetpotato flakes, canned grape juice, frozen french fried potatoes, peanut butter, raisins, dried eggs, rolled oats, and concentrated orange juice. In addition, yield and quality information on new forms of foods has been obtained. This information on recipes, yield and quality is essential for school lunch managers who are in charge of feeding almost 19 million children in the National School Lunch Program.

3. Color and texture of vegetables. Work was begun on procedures for improving color retention in green beans during food service. Green beans held on a steam table for 30 minutes will lose most of their chlorophyll. Acids formed in the vegetable while held on the steam table are responsible for most of the color loss. Addition of a small amount of a mixture of calcium acetate and magnesium carbonate to the water before cooking of the vegetable will retard subsequent color loss in the green beans while held on the steam table. Panel evaluation indicates that the additive does not have an unfavorable effect on texture or color of the green beans.

RPA 701 - INSURE FOOD PRODUCTS FREE FROM TOXIC RESIDUES FROM AGRICULTURAL SOURCES

A. Vegetables

Asparagus grown in soil treated with the herbicides Monuron, Amiben, Diphenamid, Linuron or 732 was judged by a taste panel to have full natural flavor when compared to asparagus grown in untreated soil. Cooked asparagus from the treated plots was superior in color. Sweet corn was not changed in flavor when grown in plots treated with different levels of the herbicide atrazine. Differences in panel scores for texture and color were not of practical significance.

Research under contract at Washington, D. C. and Berkeley, California was completed on the effects of home and commercial food preparation on removing insecticides present near tolerance level on a variety of vegetables. DDT, carbaryl, and malathion were in general greatly reduced by preparation procedures. Peeling, where applicable, removed residues almost completely. Parathion was used on spinach and broccoli and in both instances was difficult to remove. This indication that phosphate insecticide residues may be persistent requires confirmation.

B. Potatoes

Pentachloronitrobenzene (PCNB), a soil fungicide used against potato scab, has an adverse affect on flavor according to a minority of judges who apparently have an extremely low tolerance of PCNB. Potatoes grown in PCNB-treated soil also were lower in free tyrosine content and showed less enzymatic browning than did untreated potatoes. This change in composition and quality caused by pesticide use is a beneficial one in that darkening of potatoes due to enzymatic browning is a problem in home and institutional food preparation.

RPA 703 - FOOD CHOICES, HABITS, AND CONSUMPTION

A. Food Consumption and Dietary Levels - 1965 Nationwide Survey

1. Quality of diets. Amounts of food used in U.S. households in 1965 were sufficient, on the average, to provide diets meeting the NRC Recommended Allowances. Half of the households had diets that met the allowances for all nutrients. These diets were rated "good." The other half of the households had diets that failed to meet allowances for one or more nutrients. Calcium, vitamin A value, and ascorbic acid were the nutrients most often found to be below allowances. About one-fifth of the diets provided less than two-thirds of the allowances for one or more nutrients. These diets were rated "poor."

At each successively higher level of income, a greater percentage of households had diets that met allowances. High income of itself, however, did not insure good diets. More than one-third, 37 percent, of households with incomes of \$10,000 and over had diets that were below the allowances for one or more nutrients. Almost two-thirds, 63 percent, of the households with incomes under \$3,000 had diets that did not meet allowances for one or more nutrients. Over one-third, 36 percent of the households with incomes under \$3,000 provided less than two-thirds of the allowance for one or more nutrients and rated poor. At this income level, poor diets were most frequent among urban households in the North Central and rural households in the South.

Fewer households had good diets in 1965 than in 1955--50 percent in 1965 and 60 percent in 1955. The proportion with poor diets increased over the 10 year period, from 15 percent in 1955 to 21 percent in 1965. Decreased use of milk and milk products and vegetables and fruit, the main sources of calcium, ascorbic acid, and vitamin A value, was chiefly responsible for these changes in dietary levels.

Estimates of the concentration and location of households with poor diets by state and county were derived by statistical methods from the 1965 nationwide food consumption survey data in conjunction with Census statistics on population and income. A relatively high proportion of poor diets was found in the counties of the South and North Central Region. No county had more than 30 percent or less than 9 percent of its households with poor diets. Counties with the greatest number of households with poor diets were those with large metropolitan areas. These estimates were made in response to a request by the Committee on Agriculture, U.S. House of Representatives, in their hearings on the Stennis Bill to provide Food and Medical Services on an Emergency Basis. The estimates were published in a report to the Committee along with an evaluation of published reports on clinical and biochemical studies of nutritional status.

2. Food use by farm and urban households. Both farm and urban households have shared in changes in food consumption in recent years but farm households have made more changes than urban in their use of all the major food groups except vegetables and fruits. As a result, farm households have become more like urban households in the foods they use. In spring 1955, farm households used 19 percent more milk than urban but only slightly more (4 percent) in spring 1965. Farm households used 7 percent less vegetables and fruits than urban families in 1955; only 3 percent less in 1965. Farm households used 33 percent less purchased bakery products per person a week in 1955, but only 18 percent less in 1965. The largest difference still exists in the use of flour and cereals. In 1965 farm households were still using more than twice as much as urban families. Continued greater use of fats and sugars by farm families is partly related to their greater use of flour and cereals. On the other hand, farm families continue to use considerably less than urban families of soups and other purchased mixtures. Some of the shifts in food habits of farm families have resulted from the decline in their production of food for home use.

3. Use of convenience foods. A larger proportion of the food dollar went for convenience foods in 1965 than a decade ago. In 1955, 27 percent of the grocery bill went for 32 types of items that were classed as convenience foods. Included were all types of canned and frozen fruits, vegetables and juices; frozen, canned and dried potatoes; ground beef, frankfurters and other lunch meat; mixtures and soups; prepared flour mixes, bakery products (including purchased bread) and breakfast cereals; instant coffee, fruit ades and punches; canned and dry milk; frozen desserts; and commercially prepared puddings, pie fillings and icings. By 1965, the part of the grocery bill that went for these same items had increased to 30 percent. The percentage increase was greater for low- than high-income families. By 1965 low-income families were spending a slightly higher percentage of their money on these convenience foods than were the higher income groups. Farm families had upped markedly the proportion of their grocery money spent on convenience foods, in part because they were buying so much more of their food and producing less.

B. Nutritive Value of National Food Supply

Significant changes have occurred in the source of vitamins A and C (ascorbic acid) in diets in the past 60 years. ARS nutritionists calculated that amounts of these two vitamins available in the per capita food supply are close to their levels before World War I. Shifts in cources of these nutrients reflect some marked changes in American food habits. In 1909-13, sweetpotatoes contributed over one-fifth of the total amount of vitamin A value; by 1967, they contributed only about one-twentieth. Much of the decline in use of sweetpotatoes came about because they are no longer a mainstay in the diets of many Southern rural

families. In 1909-13, potatoes and sweetpotatoes accounted for over a third of the total amount of vitamin C in the national diet; now, the proportion is about a fifth. Other vegetables and fruits, including the dark green and deep yellow vegetables, now contribute a much larger share of the vitamin A value than potatoes and sweetpotatoes. The proportion of vitamin C provided by citrus fruit has increased fourfold over the past half century.

C. Food Acceptance and Food Habits

The amounts of foods consumed and rejected by tenth grade girls and boys at four Louisiana high schools were determined from the weights of foods served and the weights left on trays on three successive days. Boys consumed more of all foods except vegetables than girls. The highest percent of waste was noted in the vegetable group (approximately 50 percent) and the second highest in fruits (30 percent). There was little waste of milk and desserts. Acceptance of certain items differed in different schools. This may have been due to different methods of preparation.

D. Nutrition Programs Service

An intensified nutrition education program was initiated following release of the findings of the study on dietary levels of U.S. households surveyed in the spring of 1965. State nutrition committee chairmen were advised of the need for this program and were urged to take part in it. Nutritionists in states not having a committee were urged to form one. Assistance was provided seven states in developing nutrition education programs. Three workshops were developed; three seminars and ten talks were given to groups involved in community nutrition committees.

Bimonthly publication was continued of Nutrition Program News, which reaches some 6,000 workers in nutrition and related fields.

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- Szmelcman, S. 1967. Supplementation of a vegetable protein mixture. *Canadian Jour. of Biochem.* 45: 959-964.
- Szmelcman, S., and Guggenheim, K. 1967. Availability of amino acids in processed plant-protein foodstuffs. *Jour. Sci. Food Agr.* 18: 347-350.
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Food Consumption and Dietary Levels--1965 Nationwide Survey

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Nutritive Value of National Food Supply

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Nutrition Program Service

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DECIDUOUS FRUIT AND TREE NUT UTILIZATION (EASTERN REGION)

Eastern Utilization Research and Development Division, ARS

USDA and Cooperative Program

Location of Intramural Work	:Scientist Man-Years F.Y. 1968:	
	: Research Problem Area	:Total
	: 403	:
Pennsylvania (Wyndmoor)	:	:
A. Chemical Composition and Physical Properties	: 0	: 0
B. Flavor	: 1.0	: 1.0
C. Color, Texture and Other Quality Factors	: 1.8	: 1.8
D. Technology - Process and Product Development	: 4.9	: 4.9
Total	: 7.7	: 7.7

Intramural program is supplemented by extramural support representing 0.8 SMY's at universities and state agricultural experiment stations^{1/}.

^{1/} RPA 403 - Chemical Composition and Physical Properties, 0.1, and Color, Texture and Other Quality Factors, 0.7.

Problems and Objectives

Continued improvement in the quality of processed fruits is essential if fruit is to hold its own as an element in the national diet. Mechanical harvesting and other changes in the growing and harvesting of fruits create problems which must be met by improved processing methods. The preservation of fruit juices with good flavor, color, and other properties is essential in maintaining good markets for these products. The development of new fruit varieties more suitable for various types of processing is an important factor in preserving markets for the fruit processing industry and protecting fruit growers against variations in price due to irregular yields from year to year.

Objectives of the research are:

1. To extend the shelf life of fresh cider without the use of chemical preservatives.
2. To develop high quality dehydrated fruit products which may be reconstituted quickly, and which may be consumed as snacks.
3. To develop an instant apple sauce of good quality from explosive-puffed dehydrated apples.
4. To develop improved methods for the processing of mechanically harvested fruits and for maintaining the processing quality of fruits harvested by this method.
5. To evaluate the processing characteristics of new fruit varieties.

Progress - USDA and Cooperative Programs

RPA 403 - NEW AND IMPROVED FRUIT AND VEGETABLE PRODUCTS

A. Chemical Composition, Physical Properties and Structure

In grant research at Temple University on the metabolism of bruised and unbruised cherries, studies were repeated using fresh fruit from 1967 crop. Mature cherries were "fed" C^{14} -labeled compounds (glucose, acetate and citrate) through the attached stem. After suitable holding periods, the fruits were inactivated by macerating in hot ethanol. The alcohol extracts and the dried insoluble solids were stored for further study. The various extracts and residues are being fractionated in order to determine where the C^{14} activity resides.

B. Flavor

Thirty components of cherry essence have been identified. Numerous other components have been detected, many of which have pronounced odor

characteristics. The carbonyl components of cherry essence are now being examined.

C. Color, Texture, and Other Quality Factors

In contract research at Rutgers University, a total of 27 new pear varieties of apparent blight resistant and desirable horticultural quality were harvested, stored, ripened and processed by canning. The raw fruit was evaluated, and after 4 to 6 months of storage the processed fruit will be examined.

Several new cherry harvesters have been evaluated for effect on product quality. In general, bruise damage was high and quality low. An estimated \$1,000,000 was lost due to reduction in quality. A procedure for reducing bruising by transferring some processing operations from the plant to the orchard has been developed. In 1967 the joint AERD-EURDD effort in mechanically harvesting of cherries is estimated to have saved \$3,000,000 in labor costs and permitted about \$9,000,000 worth of cherries to be harvested in areas where the crop was too light to be hand-harvested.

D. Technology - Process and Product Development

Explosion puffing has been successfully applied to the dehydration of York Imperial and Golden Delicious apple pieces. Dried applesauce made from a blend of these varieties together with sugar and citric acid and pie segments of York Imperial are being prepared for institutional market tests.

The substitution of sucrose for the monosaccharides in apples has made possible the preparation of explosion-puffed apple snacks which retain their crispness well.

A commercial 6-lamp unit for ultraviolet irradiation of cider, made to our specifications, was purchased and evaluated under commercial conditions. This process extends shelf life without heat or added preservatives. The availability of such equipment should hasten the adoption of the process by cider makers, and encourage the sale and distribution of fresh apple cider by dairies, since it need contain no added preservative.

The reduction of time for lye-peeling of apples obtained by the use of wetting agents is independent of that obtained by our alcohol dewaxing step, so that lye exposure can be reduced to 2 minutes or less at 140°F., using both. Calyx removal from the product is still a problem.

Publications and Patents - USDA and Cooperative Programs

RPA 4-3 - NEW AND IMPROVED FRUIT AND VEGETABLE PRODUCTS

Color, Texture and Other Quality Factors

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Gaston, H. P., Levin, J. H., and Whittenberger, R. T. 1968. Ten years of progress in machine-harvesting fruit -- where we are, and where we go from here. Mich. State Hort. Soc., Annual Report, 97, 54-59.

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Tennes, B. R., Levin, J. H., Diener, R. G., and Whittenberger, R. T. 1967. Firmness and pitter loss studies on tart cherries. Am. Soc. Agr. Eng., Paper 333, 14 pp.

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Technology - Process and Product Development

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VEGETABLE UTILIZATION (EASTERN REGION)

Eastern Utilization Research and Development Division, ARS

USDA and Cooperative Program

Location of Intramural Work	:Scientist Man-Years F.Y.1968 :	
	: Research Problem Area	: Total
	403	
Pennsylvania (Wyndmoor)		
A. Technology - Process and		
Product Development	2.5	2.5
Total	2.5	2.5

Intramural program is not currently supplemented by extramural support.

Problems and Objectives

Economic and social factors are accelerating the trend towards processing greater amounts of the vegetable production. Utilization, as processed rather than fresh vegetables, provides a constant source of supply with less price fluctuation. Mechanical harvesting of vegetables minimizes the need for temporary farm labor forces.

Emphasis in research is on improvement in processing technology, particularly for dehydrated products. Consumer preference is shifting to "convenience" foods. Modern military feeding needs products with high bulk density which do not require refrigeration and are rapidly rehydratable.

Many dehydrated vegetable products rehydrate extremely slowly, and are limited in size, restricting utility of the products.

The major objective of this research is to perfect the explosion-puffing process to provide dehydrated vegetables which are rapidly rehydratable, cook in the same or less time than their fresh counterpart, and have good initial flavor and storage stability at room temperature.

Progress - USDA and Cooperative Programs

RPA 403 - NEW AND IMPROVED FRUIT AND VEGETABLE PRODUCTS

A. Technology - Process and Product Development

1. Quick-Cooking Dehydrated Vegetable Pieces

Research on the batch explosive-puffing of celery has been continued. The Pascal variety, both California and Florida grown, has been used as raw material. Water-blanching in 1/2% sodium bicarbonate solution (pH 8.2 to 8.6) is essential in retaining the green color. Celery from both areas yielded a product of excellent color, rehydrating in 4 minutes simmering in water. The Florida variety, however, was not acceptable because of toughness. The California variety had excellent texture and was tender. Favorable operating conditions for the batch process have been determined.

2. Dehydrated Mushroom Products

Dehydration studies on mushroom pieces have resulted in the development of an economical method of making a dry product of acceptable flavor and color. Drying temperatures as high as 200°F. had very little or no effect on initial flavor and storage stability. Of all the chemicals commonly used for controlling color, only sodium bisulfite was found to give satisfactory results and then under carefully controlled conditions of concentration.

Publications and Patents - USDA and Cooperative Programs

RPA 403 - NEW AND IMPROVED FRUIT AND VEGETABLE PRODUCTS

Technology - Process and Product Development

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Drum-dried mushroom powder--A new product. U. S. Agricultural Research
Service, ARS-73-53.

POTATO UTILIZATION (EASTERN REGION)

Eastern Utilization Research and Development Division, ARS

USDA and Cooperative Program

Location of Intramural Work	:Scientist Man-Years F.Y. 1968		
	: Research Problem Area		:Total
	: 403	: 901	:
Pennsylvania (Wyndmoor)	:	:	:
A. Chemical Composition and Physical Properties	: 4.1	: 0	: 4.1
B. Color, Texture and Other Quality Factors	: 4.1	: 0	: 4.1
C. Technology - Process and Product Development	: 2.0	: 2.5	: 4.5
Total	: 10.2	: 2.5	:12.7

Intramural program is not currently supplemented by extramural support.

Problem and Objectives

The welfare of the potato industry depends on continuing the present trend to use increasing amounts of the potato crop for processing into products such as chips, French fries and dehydrated potatoes. Processing of potatoes, however, poses several problems, the most important being disposal of potato wastes. Antipollution laws may force some plants out of business, particularly the potato starch plants which provide growers and processors with an outlet for cull potatoes. Another area of concern relates to predicting and controlling processing characteristics of potatoes. In order to extend the processing season through the winter months, fall-harvested potatoes are generally placed in cold storage where excessive amounts of sugar accumulate, requiring a lengthy reconditioning treatment before processing. No potato variety can be chipped directly out of storage. Some cannot be reconditioned successfully. Research is also needed to provide new and improved processed potato products.

Major objectives of present research are:

1. Developing technology for recovery of protein and amino acids from potato waste.
2. Developing technology for evaluating potatoes for processing, controlling browning during processing, and predicting quality at time of consumer use.
3. Perfecting the explosion-puffing process to provide new and improved dehydrated potato products.

Progress - USDA and Cooperative Programs

RPA 403 - NEW AND IMPROVED FRUIT AND VEGETABLE PRODUCTS

A. Chemical Composition and Physical Properties

1. Potato Lipids. An "unknown" fraction of fatty acids found in relatively great concentration in immature tubers has been shown to be a mixture of three unsaturated C18 acids and the C-23 and C-24 saturated acids. The fraction containing these acids decreases to zero in mature tubers.
2. After-cooking Discoloration. In any lot of potatoes, a direct correlation was found between degree of after-cooking blackening and size of tuber. The following characteristics, which are more likely in larger tubers, favor discoloration: (a) low organic acid content, especially citric; (b) high potassium/citric acid ratio; (c) high polyphenolic content; (d) high sodium content; (e) low citric acid/polyphenolic ratio. Specific gravity is not related to blackening.
3. Potato Proteins. Conditions have been established permitting replication of disc electrophoresis patterns for potato tuber proteins. A study of

variability within tubers of the same plant, row, field, and area and variety has indicated that each tuber variety does have a characteristic pattern, though differences are sometimes minor. A survey of the range of protein and free amino content of potato varieties is in progress.

4. Reducing Sugars and Enzyme Activity in Stored Potatoes. Potato tuber invertase inhibitor has been characterized; it inhibits several other plant invertases and may be useful for invertase classification. Biochemical analysis has identified potato clones with unusually low reducing sugar after storage. Progeny will be analyzed to determine transmission of the desired characteristic. Selected seedlings are being assayed for sucrose synthetase, amylase, invertase and its inhibitor. Agricultural carbamates and mild virus x infection do not affect sugar transformations.

This fundamental research on composition and properties of potatoes is needed as a basis for evaluating potatoes for processing and for controlling color and other properties during processing.

B. Color, Texture and Other Quality Factors

1. Frozen French-fried potatoes. Both crust shear and area under the entire shear curve of French-fried potatoes are proportional to specific gravity of the raw stock, though such differences cannot be detected by a panel. A great deal of data on potato samples of varying origin and history must be accumulated before a shear test can be useful for predicting quality of frozen French-fried potatoes after storage.

2. Pigments Formed in Potato Frying. The use of microwave heating to finish potato chips reduces loss of amino acids and sugars by one-half and one-third, respectively, as compared to conventional fat finishing. While intermediate browning compounds were present in considerable quantities in the microwave finished chips, the production of brown pigments was diminished.

Work continues on use of a model system to examine intermediates in amino acid and sugar reactions under chip frying conditions. Techniques for isolating intermediates have been developed using a product of the isoleucine-glucose reaction. Gamma-amino butyric acid is the most reactive amino acid with glucose.

C. Technology - Process and Product Development

1. Quick-cooking Dehydrated Potato Products. It has been determined that the off-flavors which sometimes develop in the explosive-puffing process for potatoes are probably due to aldehydes formed from the Strecker degradation, a reaction between certain amino acids and sugars, and that these off-flavors develop in the gun. Attempts to block the reaction by reacting the carbonyl group with calcium or magnesium ions were unsuccessful. Soaking potato dice 1 hour in water at 160°F. removed enough of the reactants to reduce the off-flavors below the taste threshold but the product lacked potato flavor and nutrients. Addition of amino acids and like substances, in the hope that

they might react with the sugars more selectively than the natural amino acids of the potato and form end products less disagreeable than the aldehydes heretofore formed, showed no improvement. Other means of blocking the Strecker degradation are under study.

2. Oil Content of Potato Chips. A significant reduction in oil content of potato chips has been obtained by modification of the pilot plant chip fryer. The potato chips are fried at a higher temperature and the lower viscosity of the hotter oil favors more complete drainage of oil from the finished chip. The changes in design of the potato chip fryer may be of commercial interest.

RPA 901 - ALLEVIATE SOIL, WATER, AND AIR POLLUTION

A. Chemical Composition and Physical Properties (no current research)

B. Color, Texture and Other Quality Factors (no current research)

C. Technology - Process and Product Development

1. Protein and Amino Acids from Potato Waste. Laboratory-scale equipment for ion exchange removal of amino acids from simulated potato starch processing waste has been installed and preliminary runs made. Reverse osmosis equipment for concentrating such waste has been acquired and preliminary tests indicate that the desired degree of concentration can be attained.

Publications and Patents - USDA and Cooperative Programs

RPA 403 - NEW AND IMPROVED FRUIT AND VEGETABLE PRODUCTS

Chemical Composition and Physical Properties

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Color, Texture and Other Quality Factors

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Technology - Process and Product Development

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RPA 901 - ALLEVIATE SOIL, WATER, AND AIR POLLUTION

Technology - Process and Product Development

Shaw, R., 1966. Recovery of edible and industrial products from effluent streams of potato processing plants. 21st Purdue Ind. Waste Conf. Proc. 13-18.

CITRUS AND SUBTROPICAL FRUIT UTILIZATION (SOUTHERN REGION)

Southern Utilization Research and Development Division, ARS

(RPA 403 - NEW AND IMPROVED FRUIT AND VEGETABLE PRODUCTS)

USDA and Cooperative Program

Location of Intramural Work	:	Scientist	:
		Man-Years F.Y. 1968	
Florida (Winter Haven)	:		:
Flavor	:	8.6	:
	:		:
Color, Texture and Other Quality Factors	:	1.1	:
	:		:
Technology--Process and Product Development	:	4.2	:
	:		:
Texas (Weslaco)	:		:
Flavor	:	2.5	:
	:		:
Technology--Process and Product Development	:	2.2	:
	:		:
Total :		18.6	:

Intramural program is supplemented by extramural support representing (a) 0.8 SMY's at State Agricultural Experiment Stations^{1/}, and (b) 1.2 SMY's at other U. S. institutions^{2/}.

^{1/} All on Chemical Composition and Physical Properties.

^{2/} Chemical Composition and Physical Properties 0.6; Flavor 0.6.

Problems and Objectives

Advances in the citrus and subtropical fruit industry are needed to utilize the already large but increasing production of these fruits to the economic advantage of growers, processors, and consumers. Research should be conducted not only to relate chemical components of citrus to its natural flavor and color but also to solve problems caused by bitterness and other off-flavors in grapefruit and oranges. New products should be developed to use more fruit, to attract consumers, and to reduce shipping costs; a particularly important aspect is utilization of a larger proportion of the fruit for food, as in comminuted whole citrus products. Processing procedures and equipment must also be improved. In addition, rapid, sensitive, and economical tests of quality must be devised to assure that the most desirable qualities of citrus and subtropical fruit are conveyed to the consumer.

Important goals of the research are:

1. To develop new and improved products from citrus and avocado.
2. To use more of the whole citrus fruit for food purposes.
3. To identify the sources of undesirable flavors in citrus and to develop methods to prevent them.
4. To expand markets by tailoring products to meet the needs and preferences of consumers.
5. To improve processing methods to preserve or enhance the natural flavor, color, and other desirable properties of citrus products.

Progress - USDA and Cooperative Program

A. Chemical Composition and Physical Properties

1. Relation of Ribonucleotides to Consumer Acceptability of Processed Products. A grant was recently awarded to the Florida Agricultural Experiment Station at Gainesville to investigate the role of ribonucleotides in consumer acceptability of processed citrus products and as an index of quality. Attempts will also be made to determine the potential of these compounds for controlling changes in the fruit that affect processed products.
2. Estimation of Peel Solids. Scientists at the Stanford Research Institute, South Pasadena, California, are conducting contract research to develop an organic acid index to assess the amount of peel solids in orange and grapefruit paste, puree, and juice. Satisfactory methods were developed for separating oranges and grapefruit into segment juice, rag, peel juice,

and pressed peel. Techniques were also devised for separating the organic acids in each fraction into free acids and combined acids and for quantitatively separating and analyzing the individual acids. These studies showed that free oxalic acid evidently is not a normal component of the segment or peel juice of either oranges or grapefruit. Since combined oxalic acid is the major acid of pressed orange peel, an "oxalate index" may provide an indication of peel solids present in orange juice. However, this technique would not be applicable to grapefruit, since combined oxalic acid is not a component of either juice or peel.

B. Flavor

1. Improved Flavor and Quality of Citrus Products. Enzyme reactions are being studied to determine their role in the development of flavor in citrus; eventually, such systems may be used to enhance flavor. In recent research, juice from mature oranges and grapefruit was shown to differ quantitatively from juice of green immature fruit in the ratio of reduced to oxidized forms of nicotinamide adenine dinucleotide (NADH/NAD). The higher the Brix/acid ratio, the higher the ratio of NADH/NAD. This correlation suggests that compounds known to affect the reduction/oxidation ratio should be investigated as possible regulatory agents of acidity in fruit on and off the tree. Mature citrus fruit has also been shown to have enzymes characteristic for metabolic reactions involving glucose, citric and malic acids, and ethanol and for the synthesis of aliphatic compounds. Although orange juice contains enzymes capable of synthesizing the β -hydroxybutyryl moiety from acetate through acetoacetyl coenzyme A, enzyme preparations from orange would not synthesize the β -hydroxymethylglutaryl moiety (BHMg) from acetoacetyl coenzyme A or from mevalonic acid from BHMg-coenzyme A. Therefore, if mevalonate is the precursor of terpenoids in the orange, it arises by reactions either outside the fruit or unique to it.

In research on the composition of essential citrus oils, six more compounds were synthesized as part of the effort to complete the collection of the 200 known components of citrus oil; 164 are now available. This collection will be useful in evaluating the contribution of individual compounds to flavor as well as providing known samples for comparison with unknown components isolated from various citrus oils. Also continuing is the analysis of the composition of aroma oil, a byproduct of the recovery of essence from orange juice and a valued flavoring additive. In an analysis of the carbonyl fraction of Valencia orange peel oil, now completed, most of the compounds isolated were aldehydes, ketones, and esters. The major compounds responsible for the unpleasant odor of stripper oil, also a byproduct, have been identified, and a method for their removal devised. Use of stripper oil in mechanics' hand cleaner is an example of an end use that would benefit if the odor of the oil were improved.

2. Prevention of Deterioration of Flavor. Sufficient quantities of four of the five known neutral flavones needed for taste evaluation are now available; the exception is sinensetin, which is being accumulated by both

isolation and synthesis. The identity of one of the unknown compounds in the neutral fraction is also being investigated. Although the principal UV maxima of this unknown is very close to that of 5,7,3',4'-tetramethoxyflavone, a comparison by thin-layer chromatography showed that it is not identical to the latter synthesized compound. Synthesis of auranetin, the 3,6,7,8,4'-pentamethoxyflavone isolated elsewhere from kamala orange peel, is being attempted.

In orange and grapefruit concentrates stored for thirteen months, hydrolysis of juice lipids to their respective fatty acid moieties occurred even at 0° F and was accelerated at 85° F; these reactions may account for changes in flavor during storage. Various citrus species, all of which have their own characteristic fatty acid composition, are being studied to determine if some species--for example, tangerine--are particularly susceptible to lipid oxidation. Fatty acid composition of seed lipids does not appreciably differ from species to species; nor is there much seasonal variation. However, the finding that the fatty acid composition of seed lipids is very different from that of the respective juice lipids indicates that crushed seeds do not extensively contribute lipids to the juice during processing. Since natural and added peroxides could not be detected in lipid extracts from stored citrus concentrates, these lipid oxidation intermediates appear to be unstable in citrus media. In another phase of the research, highly colored extracts from orange peel raised the color-grade of poorly-colored juice at concentrations as low as one drop to 30 ml.

In contract research at Ohio State University Research Foundation, Columbus, Ohio, a number of variables are being studied for their effect on browning of sugar-amino mixtures in aqueous solutions. Factors investigated include molar ratio of amino acid to sugar; water content; pH; and presence of various organic components, such as acids, sugars, and amino acid. Prevention of browning reactions would help extend the storage life of citrus products such as orange juice crystals.

3. Bitter Constituents and Related Components of Grapefruit. A major achievement in recently terminated research on bitterness in grapefruit products was development of a new method for the biosynthesis of radioactive naringin and its tasteless isomer, naringenin-7 β rutinoside. In a related project, the six major flavanone rhamnoglucosides in grapefruit--three of which are bitter and the other three, their tasteless isomers--were determined quantitatively in fruit harvested at monthly intervals. Since the maximum formation of the bitter flavone naringin is confined to a relatively brief period early in the season, cultural practices, such as setting the fruit later, may help improve its flavor. Synthesis of lycopene and carotene in the flesh of Redblush grapefruit and synthesis of carotenoids in the flesh of Ruby blood oranges were influenced by temperature, whereas formation of anthocyanin in blood oranges was affected by both temperature and maturity. Evaluation of climatic factors may lead to more accurate methods of predicting the time that fruit reaches maturity and optimum quality for processing.

C. Color, Texture, and Other Quality Factors

1. Extracts from Peel to Enhance Color. Finely ground peel of early and mid-season varieties of oranges was extracted with normal hexane to yield highly-colored pigments that appear to be useful in improving the color of juice. Treatment of the colored extracts with alcoholic sodium hydroxide darkened their color and removed brown and green pigments; this result may indicate that chemical changes are occurring.

D. Technology--Process and Product Development

1. Enzymatic Debittering of Grapefruit Products. Debittering grapefruit sections and juice by the use of naringinase at relatively low levels was attempted in contract research conducted by the Florida Agricultural Experiment Station at Lake Alfred. Since Florida grapefruit contained little bitterness during the 1967-68 season, it was necessary to test off-bloom fruit. A workable system was devised for adding naringinase to jars of hand-sectioned grapefruit. The pack of sections produced will be evaluated by taste tests to determine the value of enzymatic debittering. Different finisher pressures used during the processing of grapefruit juice did not cause a significant difference in naringin levels. Analyses of juice to which naringinase had been added before it was canned showed that pasteurization had completely inactivated the enzyme so that it was unable to decrease bitterness in the juice during storage.

2. New and Improved Products from Citrus and Subtropical Fruit. To utilize a larger proportion of whole fruit, research has begun on the preparation of various products from comminuted citrus. Preliminary work concerned the utilization of water-soluble extracts from the peel of grapefruit and oranges. Concentrates of the extracts contained a substantial quantity of sugar. Acid hydrolysis only slightly reduced the bitterness of the grapefruit extracts. Grapefruit peel steeped in hot water, dried at 105° C, and then ground into a coarse flour did not taste bitter but did retain a slight citrus flavor and aroma. Samples of comminuted whole grapefruit and oranges, as well as their peel, pulp, and rag, have been frozen to provide a source of material during the summer months, when citrus is unavailable.

Foam-mat dried products also offer promise of increased consumption of citrus. In research conducted in cooperation with the Florida Citrus Commission and the Western Utilization Research and Development Division, laboratory procedures were developed to permit flavoring additives for foam-mat dried citrus crystals to be encapsulated in molten sugar, as done commercially. This technique makes it possible to compare different additives that are available only in small quantities. Another new system has been developed for converting orange essence to an anhydrous form so that it can be used in the crystals. When this dry essence and commercial "locked-in" peel oil were incorporated into orange crystals, samples of instant juice tasted more like fresh fruit. The use of higher oil levels, acceptable to untrained tasters, has considerably increased storage life

of the crystals. But there has been improvement not only in the product but also in the process: the combination of densifying, grinding, and sieving after dehydration into a continuous system has increased its attractiveness to industry.

Another approach to developing new and improved products is the use of freeze-drying. Samples of sugar-water solutions, orange juice, and grapefruit juice having concentrations of solids ranging from 10 to 60% were frozen, ground to different particle sizes, and then freeze-dried under standard conditions. Moisture was removed more easily and completely from samples having smaller particle size. This effect on drying rates was more pronounced when the concentration of solids was high. Thus, high-Brix solutions, in which the dried layer provides a limiting factor for moisture removal, would be easier to freeze-dry if they were ground to finer particle size. Freeze-drying has potential for providing additives to enhance the flavor of citrus products--for example, the flavor of foam-mat dried orange powder was improved by the addition of freeze-dried orange juice containing orange essence.

In addition to research on freeze-dried citrus, a freeze-dried avocado salad product was prepared and retained acceptable flavor when it was stored under nitrogen or in vacuum for 48 weeks at 40° F or below, 16 weeks at 68° F, and 3 weeks at 100° F. Its color was stable--that is, there was no loss of carotene--at all storage temperatures for 48 weeks when air was excluded. The carotenes are among the most labile components of the system. Since the carotene content in air packs decreased far more rapidly than did unsaturated acids, preferential oxidation of the carotenes may have a sparing effect on the autoxidation of the unsaturated fatty acids. Control of the oxidation and/or autoxidation of the unsaturated acids may be a better approach to stabilizing the flavor and odor of certain dehydrated foods than is prevention of oxidation of β -carotene per se.

Publications - USDA and Cooperative Program

Flavor

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Technology--Process and Product Development

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General

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VEGETABLE UTILIZATION (SOUTHERN REGION)

Southern Utilization Research and Development Division, ARS

(RPA 403 - NEW AND IMPROVED FRUIT AND VEGETABLE PRODUCTS)

USDA and Cooperative Program

	:	Scientist	:
Location of Intramural Work	:	Man-Years F.Y. 1968	:
Florida (Winter Haven)	:		:
Technology--Process and Product Development	:	1.1	:
Louisiana (New Orleans)	:		:
Technology--Process and Product Development	:	1.2	:
North Carolina (Raleigh)	:		:
Technology--Process and Product Development	:	5.2	:
Texas (Weslaco)	:		:
Technology--Process and Product Development	:	2.7	:
Total	:	10.2	:

Problems and Objectives

The market for fresh vegetables has suffered from the effects of rapid spoilage, seasonal surpluses, and increasing demand for convenience foods. Stable, attractive, and convenient processed vegetable products must therefore be developed. However, much research is needed to solve problems incurred in the processing. For example, although most of the cucumber crop is brine-cured, spoilage during curing frequently causes high losses. To increase the utilization of dehydrated sweetpotatoes, their shelf-life should be extended and new products developed to combine the flakes with other foods. Celery, already an important flavoring ingredient, could become much more widely used if factors responsible for variations in the intensity of flavor could be controlled during processing and if more convenient products were developed. To improve processed vegetables, there is also need to determine the effect of climate, soil, cultural practices, and variety upon the raw material, particularly for vegetables like tomatoes, in which color, flavor, and texture are frequently poorer when they are grown in warm instead of temperate regions.

More specific objectives of the research are:

1. To identify the effect of different characteristics of raw vegetables on quality of the processed products.
2. To improve processes for fermented vegetables, particularly cucumbers.
3. To modify and enrich products from sweetpotato puree and flakes.
4. To develop products having improved natural celery flavor.
5. To develop new and improved products from other southern-grown vegetables, such as tomatoes and carrots.

Progress - USDA and Cooperative Program

A. Chemical Composition and Physical Properties

1. Purification of Inhibitor of Enzyme That Softens Cucumbers. In the final stages of a grant to the Research Triangle Institute, Durham, North Carolina, the crude pectinase inhibitor extracted from the leaves of sericea and previously identified as a polymeric pro-anthocyanidin based on delphinidin was purified almost fourfold, as measured by inhibition of activity of the enzyme. This natural inhibitor prevents enzymatic softening of fermenting cucumbers, and it may serve the same function for brined cherries. Another potential use is as a viricide for such organisms as the tobacco mosaic virus.

B. Technology--Process and Product Development

1. Fermented Cucumber and Other Vegetable Products. In fourteen varieties of cucumbers, differences existed in total carbonyl content as well as in the ratio of saturated to unsaturated carbonyl compounds. Although the total carbonyl content was lower in fruits with large diameter, a higher proportion of these carbonyls consisted of the unsaturated type. A combined physical-chemical sanitizing treatment was devised as a replacement for heat-shocking in the fermentation of cucumbers; anticipated benefits include lower cost of equipment and treatment and higher rate of processing bulk cucumbers. In related research on the autoxidation of carotenes, radioactive β -carotene added to precooked dehydrated sweetpotato flakes stored in an oxidizing atmosphere behaved the same as native carotenes. The end products of carotene oxidation in the flakes appeared to be low molecular weight fragments, including carbonyls, and polymers. Since carotenes are obviously involved in lipid oxidation and the development of off-flavor, their role must be defined before optimum storage conditions can be selected for processed foods. Various phases of the research are conducted in cooperation with the Pickle Packers International, Inc., and the North Carolina and Michigan Agricultural Experiment Stations.

2. New and Improved Dehydrated Sweetpotato Products and Processes. In the processing of Goldrush sweetpotatoes to make precooked flakes by the enzyme activation method, heating is a critical step, affecting gelatinization of starch and influencing the α -amylolytic action that controls the conversion of starch. The conditions required for cured potatoes, in which the enzyme concentration is high, differ from those optimal for freshly harvested roots, in which amylolytic activity is limited. The remarkable constancy of glucose and sucrose during all processing steps, despite wide variance in the raw roots, suggests two types of amylolysis: one functioning during storage to effect changes in sucrose and glucose, the other during heating to produce maltose alone. Other experiments showed that larger screen size used in a hammer mill improved the quality of flakes from uncured sweetpotatoes. Although samples of drum-dried sweetpotato pie mix packed in nitrogen were rated slightly better than those packed in air, the latter were judged fair to good after storage for thirteen months.

3. More Flavorful Dehydrated Celery Products. A faster and more efficient procedure for obtaining high quality celery essential oil in good yield from celery waste is being developed by use of a recently acquired laboratory evaporator. Research toward identification of major carbonyl compounds in celery oil is continuing. Microsaponification and esterification procedures were perfected to permit the total reaction mixture to be examined by gas chromatography. By these techniques, three esters were identified, and six other esters were tentatively identified. A carbonyl compound whose odor resembles that of apples was isolated from celery oil, and attempts are being made to synthesize it. These studies of the chemical composition of celery essential oil suggest that it is highly complex and that the flavor profile of fresh celery cannot be attributed to only a few compounds.

4. Improved Tomato and Other Vegetable Products. In cooperation with the Texas Agricultural Experiment Station, Crops Research, and industry, innovations in food technology are being applied to the development of improved products from southern vegetables. In experiments conducted during 1967, Chico variety tomatoes peeled in a hot calcium chloride solution picked up much more calcium than did tomatoes tested in 1965 and 1966. Many variables, such as growing conditions, variety, and maturity, evidently affect the toughness of tomato skin, which in turn causes variability in the time required to split the skins in the calcium solution and thus in the desired firming effect. Other research was directed to finding a substitute for citric acid, which is now used in canned salad pack tomatoes but causes a harsh, biting taste. However, the four acids tested--maleic, fumaric, lactic, and d-tartaric--did not improve the flavor. Recently initiated work concerns the processing characteristics of tomatoes, with emphasis on pectin and its quality. Molecular sieve fractionation columns have been set up, and preliminary experiments are being conducted on flow rates, pressure heads, and separations. Tomatoes of known background and commercial quality have been planted. In still another phase of the work, extreme ranges in the concentration of total carotenoid pigments were found among twenty-four varieties of carrots analyzed for carotenes and xanthophylls.

Publications - USDA and Cooperative Program

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CITRUS AND SUBTROPICAL FRUIT UTILIZATION (WESTERN REGION)

Western Utilization Research and Development Division, ARS

USDA and Cooperative Program

Location of Intramural Work	: Scientist Man-Years F.Y. 1968		
	: Research Problem Area :		
	: 403	: 901	: Total
California (Albany)	:	:	:
Flavor	: 2.0	: -	: 2.0
Technology--Process and Product Development	: 1.2	: 1.0	: 2.2
California (Pasadena)	:	:	:
Flavor	: 2.0	: -	: 2.0
Color, Texture and Other Quality Factors	: 3.7	: -	: 3.7
Technology--Process and Product Development	: 2.3	: -	: 2.3
Hawaii (Honolulu)	:	:	:
Technology--Process and Product Development	: 2.0	: -	: 2.0
Total	: 13.2	: 1.0	: 14.2

Intramural program is supplemented by extramural support representing (a) 0.9 SMY's per year at State Agricultural Experiment Stations.^{1/}

^{1/} RPA 403 - Color, Texture and Other Quality Factors 0.3 SMY.

Problems and Objectives

The economic stability of the citrus and subtropical fruit industries in the Western Region is dependent upon effective utilization of fruit that cannot be accommodated on the fresh fruit market. Ineffective utilization of products is continuously increasing processing costs and resulting in decreased returns to the grower. Also, deterioration of flavor and color in processed citrus and subtropical fruit products imposes severe limitations upon the economic stability of the industry. New and improved fruit products are needed. The reduction of water pollution is another critical problem for the fruit processing industry. Needed are methods for processing brines so as to reduce the effluent salt contents of processing plants.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Improving stability and flavor of non-frozen fruit juice concentrates and purees.
2. Developing citrus products with improved flavor and color stability.
3. Processing mechanically harvested dates.
4. Developing sweeteners from citrus constituents.
5. Recovering processing brines for reuse to reduce pollution.

Progress - USDA and Cooperative Programs

RPA 403 - NEW AND IMPROVED FRUIT AND VEGETABLE PRODUCTS

A. Chemical Composition and Physical Properties (no current research)

B. Flavor

1. Quality and Stability of Fruit Concentrates and Purees. The modified WURVAC process for recovering volatile flavors has been thoroughly tested with apple and orange juices. Analyses show that 60 to 70% of the aroma compounds in the feed are recovered. Commercial orange essence has been concentrated as much as tenfold in preliminary experiments using liquid carbon dioxide extraction. Almost all significant aroma compounds in orange essence are easily extracted by liquid carbon dioxide, with the orange oil compounds extracted most easily. Optimum conditions for maximum essence concentration have not yet been determined. Two components resulting from the photolysis of nootkatone have been identified. One is an unusual dihydronootkatone; the other compound is the result of an unusual intramolecular cyclization.

2. Flavonoid Chemistry of Citrus. Several phenolic glucosides were prepared by partial enzymatic hydrolysis of corresponding rhamnoglucosides. Naringinase was partially deactivated by controlled pH and temperature conditions so that the glucosidase activity was lost while the rhamnosidase activity was retained. With partially deactivated enzymes good yields of hesperetin 7-glucoside, prunin and phloracetophenone 4'-glucoside were obtained. In addition, hesperetin dihydrochalcone glucoside was prepared in 50% yield based on hesperidin using the new enzymatic hydrolysis. This compound which offers promise as a commercial sweetener can thus be obtained in better yield and more conveniently than by acid hydrolysis.

Detailed structure analysis of vicanin and di-C-glycosyldiosmetin provided the first such analysis of this type of flavone.

Zapoterin was shown to be a C₂₆ limonoid, 12- α -hydroxyobacunone. 7- α -obacunol was found to be naturally occurring. This is the first discovery of a 7-hydroxy limonoid in the Rutaceae, although 7-hydroxy limonoid derivatives are common in the Meliaceae.

C. Color, Texture, and Other Quality Factors

1. Citrus Color and Bitterness. Limonoic acid A-lactone (a limonin A-ring monolactone) was specifically identified as the nonbitter precursor of bitter dilactone triterpenoid, limonin. The nonbitter compound which is present in navel orange tissues is converted to limonin during juice processing and results in bitterness.

Semi-beta-carotenone and beta-carotenone were structurally identified as the deep red pigments isolated from the fruit of citrus relatives Murraya exotica and Triphosia trifolia. Semi-beta-carotenone is also detected in stored lemons which exhibit a bronzed discoloration.

Lemon, orange, and grapefruit juices have been analyzed for nucleic acids and phospholipids. Essentially all the phosphorus contained in these juices was accounted for in the following fractions: inorganic P, lipid P, small-molecular-weight organic P, nucleic acid P, and protein P. Detailed phosphorus composition will aid in establishing authenticity of citrus fruit juices.

2. Chemical and Physical Factors Affecting Quality of Mechanically

Harvested Dates. Separated tissues of grade-classified dates were examined before and after treatments designed to soften the fruit. The inner mesocarp of number 1 dry date has a lower ratio of reducing to non-reducing sugars than other tissues studied, suggesting that inversion starts later or proceeds slower in the inner mesocarp. An assumption is made that inversion is important during post-harvest softening and that hydration is necessary for inversion. Therefore, hydration procedures should be sought that will effectively deliver moisture to the inner mesocarp tissue. Number 1 dry dates were incubated after vacuum infiltration

with water. At 35° C. considerable cell wall breakage or dissolution had occurred in 4 hours, and the condition increased with time through 24 hours. The tissue became similar to that of natural dates. Shear force data suggested that the incubated number 1 dry dates were as soft as natural dates by the end of 4 to 7 hours but histological studies indicated that cell walls were not similar to those of natural dates until a longer period of incubation had transpired. Observations on number 1 and number 2 dry dates support the idea that these dates are immature at a time when moisture is lost too rapidly for ripening to occur. This contract research is conducted at the University of California at Riverside.

D. Microbiology and Toxicology (no current research)

E. Technology--Process and Product Development

1. Tropical Fruit Products. Mangos were processed to puree and canned and frozen slices. Heat treatment sufficient to inactivate catalase renders mango puree more stable during freezing storage. Nectars made from the puree of unpeeled mangos were preferred to those made from peeled fruit. Blanching before freezing in syrup yielded a mango product that was preferred to unblanched controls.

Guava puree in freezer storage had remarkable stability for 9 months. Heat treatment to inactivate enzymes, deaeration, or both treatments failed to improve aroma or flavor when compared with no heat treatment. Sensory evaluation of nectars failed to distinguish between acid and sweet guavas. Guava puree concentrate was irradiated in a gamma ray source at various levels up to 1000 krad and the effect on stability and quality noted. Microbial cell count on the inoculated pack was reduced in roughly linear fashion with increasing dosage. Spoilage occurred in all samples but rate of spoilage was reduced by irradiation. Temperature of storage had a greater effect than irradiation. No substantial change in color was seen.

2. Lemon Oil Stability. Qualitative studies have demonstrated the presence of a large number of components in commercial lemon peel oil. Little attention had been given to relative proportions or influence of individual components on quality and stability of oil. Procedures are being developed to permit quantitative estimation of various components. Major chemical groupings of lemon oil are being fractionated and tests developed to estimate individual members of homologous groups of compounds.

3. Methods for Processing Mechanically Harvested Dates. Simple methods have been developed to effect a moderately good sort of mechanically harvested dates into maturity classes. These methods are based on size and resiliency of the dates.

Excellent progress has been made in processing various classes of mechanically harvested dates to salable condition. Immature dates can be ripened by freezing to rupture cells and release enzymes, followed by

tempering at refrigerator temperatures first and further tempering and drying at 90 to 100° F. Over-dry dates, partially mature, can be ripened by rehydrating them to the proper moisture level, followed by 24 hours of tempering at 100° F. The processed dates develop an excellent color and texture.

4. Desert Grapefruit Products. Extending previous research on blends of grapefruit juice with juices and purees of other fruits and berries, studies were initiated on color and flavor stability of grapefruit juice products containing strawberry and raspberry juice. In contract research conducted at the University of Arizona in Tucson a method for measuring color stability was developed. Effects of container type, storage temperature and additives on stability of grapefruit drinks containing raspberry and strawberry juice are being investigated. Mid-season desert grapefruit juice of low bitterness when blended with peach and apricot purees was highly acceptable to consumer test panels. Consumer ratings of such blends made with early-season grapefruit, which is more bitter, indicate that grapefruit juice of relatively high solids and low bitterness is necessary for good acceptance.

RPA 901 - ALLEVIATE SOIL, WATER, AND AIR POLLUTION

A. Chemical Composition and Physical Properties (no current research)

B. Flavor (no current research)

C. Color, Texture, and Other Quality Factors (no current research)

D. Microbiology and Toxicology (no current research)

E. Technology--Process and Product Development

1. Simplifying Disposal of Food Processing Wastes. Plans were drawn for a commercial-scale unit for the recovery of olive storage brine by passage through a charcoal column and made available to the National Cannery Association. The Research Foundation of the National Cannery Association was awarded a demonstration grant by the Federal Water Pollution Control Administration, partially supported by the California olive industry to study reconditioning of food processing brines. Initially, olive storage and processing brines will be used in the commercial-scale unit and their reuse potential evaluated. Scientists from the Western Utilization Research and Development Division will participate as consultants in this project.

In contract research, the National Cannery Association found that small-sized Mission olives can be stored for six months in propylene glycol-diethyl pyrocarbonate or glycol-benzoic acid-sorbic acid mixtures. Shriveling that occurs during storage in glycol-bacteriostat systems is removed after soaking with water and curing with potassium hydroxide solutions. Salt level in olives stored in ammonium sulfate brine can be reduced by treatment with potassium hydroxide solutions. Ammonium sulfate level is reduced very

slowly by all types of washing procedures. Long-term aeration of olives in potassium carbonate suspension facilitates the development of dark skin pigmentation in smaller-sized Mission olives that were difficult to color. There was no significant change in monoglyceride content of olives after soaking, lye curing, aeration, washing and canning. Taste panel ranking of olives canned after various brine storage periods appeared to confirm the storage time of 12-15 weeks as critical for off-flavor development.

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RPA 403 - NEW AND IMPROVED FRUIT AND VEGETABLE PRODUCTS

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DECIDUOUS FRUIT AND TREE NUT UTILIZATION (WESTERN REGION)

Western Utilization Research and Development Division, ARS

USDA and Cooperative Program

Location of Intramural Work	Scientist Man-Years F.Y. 1968			
	Research Problem Area			Total
	403	601	702	
California (Albany)				
Chemical Composition and Physical Properties	3.0	-	-	3.0
Color, Texture and Other Quality Factors	8.9	-	-	8.9
Microbiology and Toxicology	-	-	1.6	1.6
Technology--Process and Product Development	11.1	7.6	-	18.7
California (Pasadena)				
Chemical Composition and Physical Properties	2.0	-	-	2.0
Washington (Puyallup)				
Technology--Process and Product Development	0.6	-	-	0.6
Total	25.6	7.6	1.6	34.8

Intramural program is supplemented by extramural support representing
 (a) 0.6 SMY's per year at State Agricultural Experiment Stations^{1/},
 (b) 0. SMY's per year at other U.S. institutions, and (c) P.L. 480 funds
 in 3 countries representing 58,640 U.S. dollars equivalent per year.

^{1/} RPA 403 - Color, Texture and Other Quality Factors 0.6 SMY.

Problems and Objectives

Fruits and nuts are valued for their unique flavor, color, and mineral and vitamin content. At harvest time, markets are glutted and growers often do not get an adequate return. Processing makes these commodities available all year and opens new markets for producers, but the unique qualities of these crops are not easily preserved by processing. New and improved products for domestic and foreign markets are needed. The control of microbial contaminants in products and the reduction of water pollution by reducing processing wastes are also critical problems for the processing industry.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Developing dried fruit and tree nut products acceptable to foreign markets.
2. Controlling microbial contaminants of fruit products.
3. Evaluating processing characteristics of Pacific Northwest berries and fruits.
4. Improving stability and flavor of non-frozen fruit juice concentrates and purees.
5. Improving piece-form and powdered products by dehydration of fruits.
6. Improving fermented fruit products.
7. Improving frozen fruit products.
8. Developing novel methods for controlling plant enzymes in processing and maturation of fruits.
9. Reducing processing wastes from peeling of fruits to minimize pollution.

Progress - USDA and Cooperative Programs

RPA 403 - NEW AND IMPROVED FRUIT AND VEGETABLE PRODUCTS

A. Chemical Composition and Physical Properties

1. Controlling Plant Enzymes. Insoluble but active papain was prepared by the reaction of the enzyme with glutaraldehyde. Insolubilized-active enzymes have many analytical applications and may have industrial applications. The metabolic pathways of the cis and trans isomers of hydroxyproline into protein in plant tissue were found to be different. The findings have

been correlated with auxin-induced growth. Several peroxidase isoenzymes were found to be secreted by plant suspension culture cells. Each isoenzyme probably plays its own particular role in plant metabolism. For this reason the peroxidase isoenzymes of tomato are being isolated and characterized.

Although the functions of steroid hormones in plants are still a mystery, it is becoming increasingly evident that they are synthesized and metabolized in the same way as in animals. Ecdysterone, a molting hormone for insects and crustaceans, is synthesized in radioactive form when radioactive cholesterol is administered to a tree, Podocarpus elata. In foxglove (Digitalis lanata), cholesterol is converted to the progestational hormone, progesterone, by way of pregnenolone. The metabolism of these substances in the plant has been studied. Progesterone was found to be a key intermediate in the synthesis of heart poisons. One of the radioactive products isolated from a primitive tomato plant, Lycopersicon pimpinellifolium, was found to be a sapogenin closely related to tomatidine and another one a certain pregnane derivative. The latter is a steroid which is well known as an industrial intermediate in the synthesis of progesterone from steroidal sapogenins and alkaloids.

B. Flavor

1. Enzymes in Apple Flavor Formation. Supported by P.L. 480 funds, The Federal Research Station for Agriculture, Viticulture and Horticulture, Switzerland, is conducting research to determine the role of enzymes in the formation of apple aroma. Volatile components of apples of the Golden Delicious and Bohnapfel varieties were isolated as oils and separated. One of the quantitatively prevalent fractions was identified as n-hexylacetate.

C. Color, Texture, and Other Quality Factors

1. Anthocyanin and Carotenoid Pigments. The decoloration of flavylum salts under reducing conditions has been studied by using reducing agents that act as hydride ion donors and those (metals) that act by one-electron donation. Colorless dimers are formed by both classes of reducing agents. The structures of these dimers have been elucidated. Experimental work on the possible biogenetic origin of flavonoid pigments has been initiated. Spectral methods for elucidating anthocyanidin structures have been refined and applied to the solution of the structure of aurantinidin. Studies of the formation of leucocyanidin-polyphenol colorless condensation products were completed.

2. Fruit Leucoanthocyanins. P.L. 480 funds are supporting research at the University of Delhi in India where a study of the chemical behavior of leucoanthocyanins in fruits is underway. A number of varieties of pears and apples were studied at an unripe stage. A proanthocyanidin, appearing to be a glucoside of leucocyanidin was isolated from the custard apple. Only fructose was found in the leucoanthocyanidins extracted by cold and hot methanol from apricot kernels. The shell of apricot seeds contains galactose

and a small amount of arabinose but no leucoanthocyanidins. Small quantities of leucoanthocyanidin were found in extracts of peel and pulp of unripe apricot. Flavan-4-ol was more resistant to mild oxidizing conditions than flavan-3-ol. Prolonged treatment of epicatechin tetramethyl ether with dimethyl sulfoxide (DMSO) was required to oxidize it to the keto form. Oxidation of flavan-3,4-diol with DMSO gave a pseudo base as the major product and traces of quercetin tetramethyl ether.

3. Tannin Degradation in Fruits. The Central Leather Research Institute in India, supported by P.L. 480 funds, is seeking biological methods for the degradation of tannins, in order to reduce astringency in fruits. Molds predominantly grow in a medium containing catechin as the sole carbon source. A. flavus previously adapted to dicatechin had the maximum efficiency to utilize catechin and produce extra-cellular enzymes. Factors influencing growth and utilization of catechin by A. flavus were standardized. Concentration of salts in growth medium influences the synthesis and excretion of enzymes that catalyze degradation of catechin to protocatechuic acid and phloroglucinolcarboxylic acid. Optimum composition of inorganic salts, organic and inorganic nitrogen sources, and other conditions of the biosynthesis were investigated. Besides being useful for nutritional requirements of A. flavus sulfate was helpful in releasing enzymes from the mycelium. Ammonium chloride favored the synthesis of enzymes but yield in the filtrate was poor.

4. Polysaccharides in Plant Cell Walls. Supported by P.L. 480 funds, the National Taiwan University in China studied the synthesis of hemicellulose polysaccharides using bamboo shoots. Glycosyl transfer from guanosine diphosphoglucose (GDPG) into a water-insoluble dilute alkali-soluble material was specifically stimulated by the addition of uridine diphosphoxylose (UDPX) while the synthesis of callose from uridine diphosphoglucose was competitively inhibited by the same xylosyl nucleotide. The stimulation by UDPX of glucosyl transfer from GDPG was supposed to be due to the copolymerization of glucose and xylose in the formation of a glucoxytan. UDPX was found to contribute the xylosyl group for the formation of a water soluble pentosan. The polymer formed may be an arabinan. The microfibrils of cell walls of bamboo shoot tissues are spindle shaped and composed of very fine short rod subunits. These structural features of the microfibrils are considered to contribute the very high rate of cell wall expansion as well as the excellent texture of this plant as an edible vegetable.

5. Clarification of Apple Juice. The Colorado State University in Fort Collins is conducting contract research to eliminate cloud and sediment from apple juice. Analyses of sediment and evaluation of commercially packed apple juice after 10 months' storage at 38°, 72° and 100° F. were completed. Samples involved four treatments: (1) regular process (gelatin clarification), (2) regular process (Polyclar clarification), (3) ascorbic acid-sodium chloride treatment of milled pulp (Polyclar clarification) and (4) fortification of juice with ascorbic acid. Ascorbic acid fortification is beneficial except for samples stored at 100° F. Those samples are darker than the non-ascorbic acid samples. Gelatin used in clarification can

react to form sediment later. Chlorogenic acid appears to be of no significance in sediment formation. The principal leucoanthocyanidin from apples has been isolated; preliminary analyses indicate this is probably a dimeric flavanoid.

6. Enzymic Browning of Deciduous Fruit. Supported by P.L. 480 funds, The Hebrew University in Israel studied the nature, activity and distribution of phenolases in deciduous fruits in order to minimize enzymic browning of products.

Browning enzymes were found primarily in the particulate fractions (chloroplasts and mitochondria) in apples, while in peaches and apricots a considerable portion of the enzyme was also present in the soluble fraction. The soluble peach enzyme is entirely distinct from the particulate enzyme of apples and apricots. Several new inhibitors of catechol oxidase were found, namely, 2,3-naphthalenediol, polyvinyl pyrrolidone and its monomer 2-N-vinyl-pyrrolidone. These agents are highly effective in preventing browning of apple slices and may have practical use in that regard. The inhibitors are ineffective against the soluble peach enzyme. Derivatives of the pyrrolidone and closely related compounds hold promise of being effective inhibitors. Catechol oxidase was found to be a family of enzymes with a variable spectrum of activity toward various substrates. This has important basic implications in the future study of the browning enzymes.

D. Microbiology and Toxicology (no current research)

E. Technology--Process and Product Development

1. Grape Juice Products. Research to devise processes for making new unfermented products from grapes and improved processes for making existing grape products has been initiated.

2. Fermented Grape Products. Progress has been made in defining the factors that determine production rates and product concentrations in reverse-osmosis concentration of agricultural products and byproducts. Experimental results indicate that production rates are limited by concentration polarization. The upper limit of concentration for fruit juices is dictated by the osmotic pressure of the concentrate.

Ion exchange of potassium for calcium in wines was shown to bring about cold stability without changing the cation/anion ratio and without introducing foreign ions to the system.

Sixty components of Concord grape essence were identified by gas chromatography-mass spectrometry methods. Of particular interest were a series of crotonate esters and a possible ethyl thio hexanoate. Comparison of Grenache juice and the corresponding wine shows more esters and some possible acetals in the wine.

Botrytis cinerea culture, extraction, and biochemistry were studied. Activity is dependent on growing temperature. Similarity of endo and exocellular enzymes was indicated.

3. Improved Piece Form and Powdered Fruit Products. Golden Delicious apple segments were osmotically dehydrated in a pilot-plant-scale apparatus in which 70% sugar syrup was pumped continuously over the fruit at 50° C. The apples, after drying to a weight reduction of 50%, were blanched in steam and frozen. Rates of rehydration of the dehydrofrozen apples were measured under various conditions and a system suitable for producing satisfactory pies was worked out. This involved a preliminary soak in water, followed by baking to complete the rehydration. Moisture determinations on a sample of low-moisture apple powder by the vacuum oven method and the Karl Fischer method showed the Fischer method to be much more reliable.

Malecki Laboratories, Inc., Chicago, Illinois, is conducting contract research to develop a continuous fluidized-bed freeze-dryer for making fruit juice powders. Good progress has been made during the initial operation of the fluidized-bed freeze-dryer. Orange juice and apple juice were spray frozen separately by aspirating them onto a spinning disk, while the entire apparatus inside of a chamber was swept by very cold gas and the inside of the chamber walls were bathed in liquid nitrogen. The frozen juice particles, all finer than 30 mesh, were collected and sized by wet screening, using liquid nitrogen. The frozen droplets were then freeze-dried in a fluidized bed. It was found that fluidizing gas temperatures above -25° C. resulted in caking of the particles. At this temperature, of course, freeze-drying is very slow. The use of mechanical stirring or adding anti-caking bodies, either glass beads or very fine anti-caking particles, resulted in a modest improvement. By these means, especially the use of glass beads, bed temperatures could be raised to -10° C.

4. New Soft Fruit and Berry Varieties for Processing. Results of tests that simulated mechanical harvesting conditions indicate that Northwest, Molalla, and Columbia strawberry varieties have the best tolerance for mechanical harvesting. Fresno was the best California strawberry tested for mechanical harvesting tolerance. Of 841 strawberry hybrids tested in 1967, WSU hybrids 1232, 1140 and 1142 had the best quality after freezing.

Mechanically harvested grapes cannot be washed in plant as the berries are often split in harvest. Dirt levels on grapes were measured and found to depend upon vineyard conditions, cover crops and irrigation systems. Grapes from light soils near dusty roads had highest dirt content. Airblast spray washing of grapes before harvesting was an effective way of reducing dirt content of grapes.

Canned cherry samples that had up to 75% bruised fruit held 24 hours before processing were of acceptable quality. Fifty-seven commercially pressed lots of apple juice clarified, filtered, pasteurized, and stored for 3 months showed no haze development.

RPA 601 - EXPANSION OF FOREIGN MARKETS FOR U.S. PRODUCTS

- A. Chemical Composition and Physical Properties (no current research)
- B. Flavor (no current research)
- C. Color, Texture, and Other Quality Factors (no current research)
- D. Microbiology and Toxicology (research included in section E)
- E. Technology--Process and Product Development

1. High- and Low-Moisture Products from Dried Fruits. A drum dryer system has been tested on pineapples, blueberries, bananas, apricots, pears, prunes, dates, boysenberries and lemon pulp sacs.

Storage stability tests on heat-treated raisin paste show that an alteration of flavor develops if the heating is conducted prior to grinding. Heating following grinding caused no major alteration of raisin flavor.

The SO₂ levels of dried apricots having 2117 and 1746 ppm SO₂ decreased nearly equally to about 550 ppm after the apricots were boiled for 30 minutes.

Dried fruit products were obtained from processing plants and analyzed for total aerobic bacteria, yeast, mold, coliforms and Salmonella. Results obtained to date indicate that total aerobic bacterial counts and yeast and mold counts are below those of other food items. No coliforms or Salmonella have been detected to date. There is a marked difference in general microbial contents of different dried fruits. Dates were found to have higher counts of organisms.

RPA 702 - PROTECT FOOD SUPPLIES FROM HARMFUL MICRO-ORGANISMS AND NATURALLY OCCURRING TOXINS

- A. Chemical Composition and Physical Properties (no current research)
- B. Flavor (no current research)
- C. Color, Texture, and Other Quality Factors (no current research)
- D. Microbiology and Toxicology

1. Radiation Sterilization of Mold Contaminants. Supported by P.L. 480 funds, the Institute of Biology and Agriculture in Austria is conducting research to discover physical and chemical methods of increasing irradiation sensitivity of yeasts and molds to reduce heat requirement for fruit juice pasteurization.

Fewer fruit juice samples showed spoilage after combined treatments with irradiation and heat (50° C.) than after irradiation treatment alone. Byssochlamys fulva shows only slight production of methyl pectinesterase. Electron microscopic investigations show that the relative radiosensitivity of germinating ascospores is correlated with fragile cell wall structure in this stage of development.

E. Technology--Process and Product Development (no current research)

Publications - USDA and Cooperative Program

RPA 403 - NEW AND IMPROVED FRUIT AND VEGETABLE PRODUCTS

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VEGETABLE UTILIZATION (WESTERN REGION)

Western Utilization Research and Development Division, ARS

USDA and Cooperative Program

Location of Intramural Work	: Scientist Man-Years F.Y. 1968			
	: Research Problem Area			:
	: 403	: 601	: 702	: Total
California (Albany)	:	:	:	:
Flavor	: -	: 3.7	: -	: 3.7
Color, Texture and Other Quality Factors	: 3.8	: -	: -	: 3.8
Microbiology and Toxicology	: -	: -	: 6.4	: 6.4
Technology--Process and Product Development	: 6.4	: 3.0	: -	: 9.4
California (Pasadena)	:	:	:	:
Technology--Process and Product Development	: 0.5	: -	: -	: 0.5
Washington (Puyallup)	:	:	:	:
Microbiology and Toxicology	: -	: -	: 0.1	: 0.1
Technology--Process and Product Development	: 0.4	: -	: -	: 0.4
Total	: 11.1	: 6.7	: 6.5	: 24.3

Intramural program is supplemented by extramural support representing
 (a) 0.9 SMY's per year at State Agricultural Experiment Stations^{1/},
 (b) 0 SMY's per year at other U.S. institutions, and (c) P.L. 480 funds
 in 2 countries representing 51,865 U.S. dollars equivalent per year.

^{1/} RPA 701 - Technology--Process and Product Development 0.3 SMY,
 RPA 702 - Microbiology and Toxicology 0.6 SMY.

Problems and Objectives

Vegetable crops are perishable and seasonal and thus subject to disadvantageous supply and price fluctuations. New products and processed products of improved quality, stability, convenience, nutritive value, safety and cost are needed to sustain domestic and build foreign markets. Processing operations must be changed to cope with the effects of mechanical harvesting and field handling of raw materials. Increased use of agricultural chemicals may require processing changes to mitigate effects of residues. Wastes from processing operations must be handled at reduced costs to prevent polluting soils and bodies of water.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Improving quality and stability of dehydrated vegetables for export.
2. Insuring removal of harmful agricultural residues in processing.
3. Protecting canned low-acid foods and other vegetable products from spoilage bacteria and from microbial contaminants.
4. Improving and developing new and improved foods by evaluating processing characteristics of new varietal selections; devising processes to create convenient, non-flatulent products from dry beans and peas; controlling the consistency of tomato products; and devising better methods for preserving the textural characteristics of frozen vegetables.
5. Alleviating soil and water pollution from vegetable processing wastes.

Progress - USDA and Cooperative Programs

RPA 403 - NEW AND IMPROVED FRUIT AND VEGETABLE PRODUCTS

A. Chemical Composition and Physical Properties (no current research)

B. Flavor

1. Aroma and Taste Components of Hops. The rate of photolysis of copululone to 4-desoxycophumulone was markedly increased by addition of riboflavin triphosphate as a photosensitizer. Analysis of green and sulfur-dried hops for the presence of methyl thiohexanoate showed that this sulfur compound (a powerful odorant) is a natural component of the hops and is not formed by the sulfur treatment. This investigation of hop components provides basic information currently needed to develop new products for use in brewing.

C. Color, Texture and Other Quality Factors

1. Improved Dry Bean Products. A dry bean fraction exhibiting a 10-fold concentration in flatulence activity was separated by ion exchange into three subfractions for controlled evaluation. Data analysis is in progress.

An alcoholic extract of beans does not inhibit carbonic anhydrase which probably is a major factor in the transport of CO₂ from the intestine. Addition to such bean extracts of appropriate enzymes, such as are likely to be present in intestinal bacteria, results in a progressive formation of a substance(s) which does inhibit carbonic anhydrase. Among substances likely to be produced by bacterial enzymic action on beans is hydrosulfide ion or sulfide ion which is an extremely potent inhibitor of mammalian carbonic anhydrase. Accumulation of CO₂ in the lower intestine associated with bean flatulence may be the result of many factors. One source of CO₂ may be bacterial fermentation of non-absorbable substances, but inhibition of CO₂ transport across the intestinal wall might also be essential to accumulation.

An assay procedure was developed for estimation of a factor in Lima and other dry beans which stimulates gas production and growth of the common intestinal anaerobe, Clostridium perfringens. Starch and simple carbohydrates did not stimulate gas production by this assay method. However, a variety of dry beans reproducibly stimulated prolific gas production. Non-flatulent, bland foods such as barley and rice produced minimal responses.

This investigation provides basic information currently needed in the development of convenient, non-flatulent food products from peas and beans.

Phytate content of Pinto beans increases during early seed development. Dry beans contain about 1% phytate, half the total acid-soluble phosphorus. This research provides basic information currently needed to develop convenient quick-cooking bean products of uniform tenderness.

2. Bean Proteins. Defatted seed meals of Acacia catechu, A. suma, Cassia occidentalis, C. obtusifolia, Mucuna pruriens, Dolichos biflorus, Glycine hispida and Pithecellobium dulce were analyzed for nitrogenous constituents at various pH. Semi-quantitative fractionation based on solubility characteristics and isolation of proteins in appreciably pure form were completed. All seeds examined contained globulin as their major protein component varying from 46 to 83% of the total nitrogen content. Amino acid composition of purified globulins is under investigation.

Albumins isolated from 5 varieties of Phaseolus seeds were analyzed for amino acid composition. All samples contained 14-18 amino acids. Chemical analysis for essential amino acid content revealed them to be of adequate nutritive value. Biological evaluations are underway.

A new amino compound from seeds of Crotalaria juncea was isolated and purified and characterized. A tentative structure was proposed.

This research at the Allahabad University in India is supported by a P.L. 480 grant to provide information necessary for the development of new and improved processes and products to increase utilization of dry beans.

D. Microbiology and Toxicology (no current research)

E. Technology--Process and Product Development

1. Physical Characteristics of Heat Processed Tomatoes. High consistency tomato juice and paste were successfully prepared on a small pilot-scale controlled pH-break processing line with a capacity up to 1000 lbs. per hour. These products were prepared in the pH range of 1.0 to 3.0 at temperatures of 190 to 200° F. Samples are in storage at 34° and 90° F. for periodic evaluation.

Other high consistency juices were prepared at pH 6.0. These juices have a tendency to gel; however, when they are mixed with juices prepared at the natural fruit pH, pastes of improved consistency are obtained after concentration. The effects of pH and temperature on losses of juice consistency and serum viscosity during processing delays were investigated. Changes at 160° F. were slight compared to damage occurring at 190° to 212° F. Within the pH range of 2.0 to 4.5, rates of viscosity loss were roughly equal for samples held at the same temperature. At pH 6.0 loss rates were several-fold those observed at the lower pH.

2. Texture of Frozen Vegetables. Microwave blanching and steam blanching of corn-on-the-cob were evaluated by sensory panel appraisal of samples stored at 0° F. Steam-blanched samples stored at -20° F. were used as reference samples. Nine-month and twelve-month storage gave similar results--no difference between reference samples and samples stored at 0° F. after the following treatments: 8 min steam, 12 min steam, 4 min microwave, and one combination involving hot water and microwave blanch. After 9 months' storage at 0° F., underblanched (by peroxidase test) microwave-blanched samples were inferior to adequately blanched samples. Eight-min steam-blanched samples were inferior to 12-min samples. The best microwave-blanched (4 min) and steam-blanched (12 min) samples contained some residual peroxidase; peroxidase-free samples (6.1 min microwave) were inferior.

Test panels detected no difference among three samples of blast-frozen asparagus which showed slight freezing damage confined to vascular and sub-epidermal tissues. They were able to distinguish them from other blast-frozen samples without damage, or from package-frozen asparagus with extensive visible damage.

With zucchini squash samples cooked for 1 min, test panels detected differences between slightly, moderately, or severely damaged blast-frozen slices. Moderately and severely damaged samples were not distinguished. With longer cooking times the differences were more apparent and panel

members expressed a significant preference for the firmest samples which were those exhibiting least observable tissue damage.

Asparagus, Snow peas, snap beans, Romano beans, corn, carrot sticks, cauliflower and Brussels sprouts were frozen by immersion in liquid Freon-12 at -22° F. and evaluated. Flat podded vegetables showed splitting along the suture during freezing. Repeated short dips in the freezant lessened the splitting. Immersion for extended periods did not cause more extensive splitting than 30 seconds immersion. Extended contact with liquid nitrogen on the other hand causes shattering of food products. Freon-frozen carrot sticks when thawed retained a crispness in texture that cannot be attained by conventional freezing. Asparagus, Snow peas, snap beans, Romano beans, cauliflower and Brussels sprouts were judged to have better texture than conventionally frozen products.

3. Improved Dry Bean Products. A convenient and economical process that will permit institutional users to process and prepare their own quick-cooking Lima beans was developed. Educational, commercial and military food preparation centers may use available equipment for processing. Dry beans are soaked overnight in a solution of common, food-grade inorganic salts. The soak solution is discarded and the beans are cooked for 10 to 15 minutes. Uncooked beans thus soaked may be frozen and stored for future use.

Large-scale processes for quick-cooking dry beans appear technically feasible for Pintos, California Small White and Great Northern beans and black-eyed peas.

A variety of legume powders stored in air for 12 months or longer developed a distinct off-odor. The off-odor, along with the fatty components, was extracted with ether. Thiobarbituric acid tests indicated relatively little malonaldehyde had accumulated, although this is usually regarded as a good index of fat rancidification. Aldehydes and ketones were not present in detectable concentrations in stored bean, pea, or lentil powders.

Drum-dried bean powder had a higher lipids content than comparable tray-dried beans or ground raw beans. Free fatty acid content of bean powders cooked before being dried was only one-eighth that of ground raw beans, indicating a contribution of the cooking step to flavor stability. Production rates per square foot of drum surface were similar on a small double-drum dryer and a larger double-drum dryer converted for use as a single-drum machine. Product quality was similar for both equipments.

4. New Vegetable Varieties for Processing. Alar (trade name) slows maturation of Brussels sprouts but tops them chemically, thus eliminating a labor cost of \$12-\$15/acre. In addition, it produces a firmer sprout and one that requires less blanching, which should result in better color. This is an example of new cultural practice which can result in improved quality of a frozen vegetable.

The Jade Cross Brussels sprout yields well in the Puget Sound area of Washington State but it would make a better frozen pack if it had more compact heads and a deeper green color. The newer hybrids, as well as the variety Hedda, appear to have characteristics that will attract more processors.

RPA 601 - EXPANSION OF FOREIGN MARKETS FOR U.S. PRODUCTS

A. Chemical Composition and Physical Properties (no current research)

B. Flavor

1. Chemistry of Vegetable Flavor Compounds. Intramural and P.L. 480 grant research is conducted to obtain basic information currently needed to improve quality and stability of dehydrated vegetables for export.

Among more than 400 persons screened for their sensitivity to odors, 10 were found who were remarkably and specifically insensitive to the odors of short chain fatty acids. Further comparisons of these "specific anosmics" with a group of 97 normal observers provided the first systematic experimental definition of a primary odor, "sweaty," and the corresponding primary odorant, isovaleric acid (3-methyl butanoic acid).

Trans-S-(1-butenyl)-L-cysteine sulfoxide cyclizes in a manner similar to the cis-propenyl analog but differs from the natural trans propenyl compound which is the natural flavor precursor of onions. Two isomers are produced in the non-natural model compounds and the structures of these isomers were elucidated. The bitter material produced enzymically when onions are crushed or the juice expressed from them was separated into four sulfur-containing components as oils. The compounds also contain oxygen. Three crystalline 2,4-dinitrophenyl sulfides were prepared from one of the bitter components by LiAlH_4 reduction and reaction with 1-chloro-2,4-dinitrobenzene. The bitter flavor and most of the typical fresh onion aroma, as well as the odor of cooked onions, arise from enzymic and chemical reactions of trans-S-(1-propenyl)-L-cysteine sulfoxide.

Preliminary experiments with a bitter substance of artichoke indicate that the bitter principle is extremely heat labile or convertible by enzymic action to yield essentially flavorless components.

Related investigations are conducted at the Biochemical Institute, Finland, supported by P.L. 480 funds. Purification and characterization of chemical structure of still unknown compounds of Allium species are in progress, including a detailed study of the biosynthesis of characteristic sulfur compounds. For comparison the biosynthesis of homologous compounds found in marine algae is under investigation. Methodology for sensitive, rapid analysis of such compounds is being improved. A probable pathway for biosynthesis of cycloalliin, a major sulfur compound of wild onion, was elucidated. Enzymic splitting of glucotropaeolin in garden cress seeds is under investigation.

C. Color, Texture and Other Quality Factors (no current research)

D. Microbiology and Toxicology (no current research)

E. Technology--Process and Product Development

1. Dehydrated Vegetable Stability. Dehydration of celery by extraction of water with alcohols greatly improves rehydration characteristics compared to commercial air-dried products. However, a simultaneous extraction of chlorophyll and other aqueous alcohol-soluble constituents occurs. Losses of solutes, including chlorophyll, can be reduced when dehydration is accomplished by suspending diced celery samples in the vapor phase of water-organic liquid azeotropic mixtures. Mixed aliphatics, isopropanol, cyclohexane, benzene, and a 1:3 mixture of isopropanol and cyclohexane were used. Rehydration indices were intermediate to the extremes previously reported for solvent-extraction and air-drying. Liquid phase extraction still occurs in the azeotropic system due to condensation on the sample surface.

Celery slices were soaked in 60% sucrose for 10 min, at room temperature before dehydration at 150° F. and bin-drying at 119° F. The sucrose-treated dried slices remained pliable but contained about 64% added sucrose. When rehydrated these slices had improved shape, size, and texture over controls. However, a series of rehydration treatments indicated that the improved appearance was due to the direct effect of sucrose on piece volume and not due to improved water binding capacity of the celery tissue.

RPA 701 - INSURE FOOD PRODUCTS FREE FROM TOXIC RESIDUES FROM AGRICULTURAL SOURCES

A. Chemical Composition and Physical Properties (no current research)

B. Flavor (no current research)

C. Color, Texture and Other Quality Factors (no current research)

D. Microbiology and Toxicology (no current research)

E. Technology--Process and Product Development

1. Changes in Pesticide Residues During Processing. Contract research at the National Cannery Association, California, was initiated on chemical changes in pesticide residues during processing of fruits and vegetables to facilitate preserving products that meet pesticide residue standards.

RPA 702 - PROTECT FOOD SUPPLIES FROM HARMFUL MICRO-
ORGANISMS AND NATURALLY OCCURRING TOXINS

- A. Chemical Composition and Physical Properties (no current research)
- B. Flavor (no current research)
- C. Color, Texture and Other Quality Factors (no current research)
- D. Microbiology and Toxicology

1. Heat Resistance, Dormancy, and Germination of Spores. Resistance of bacterial spores to dry heat can be changed from a sensitive to a resistant state in the same way as shown previously for resistance to moist heat. Sensitized spores of B. stearothermophilus had about the same survival rate at 105° C. as resistant spores at 125° C. Exposing spores to acid and then washing and drying them produces the sensitive state. Neutralization by metal ions produces the resistant state. A process for sterilizing low-acid foods based on the conversion and retention of the sensitive state of spores in the food has been improved by use of CO₂ in the reneutralized food. The resultant temporary lowering of the pH during the heat process increases the sensitivity of spores to heat.

Several heterocyclic dicarboxylic chelating agents were synthesized for a correlation of geometry, calcium-binding strength, and other parameters with efficacy in a calcium-dipicolinate type germination. X-ray crystallography of several of these synthesized compounds is underway to test a hypothesis for the mode of action of calcium-dipicolinate type germination.

These investigations to provide basic information currently needed to develop improved methods for preserving low-acid foods were supplemented by a recently concluded P.L. 480 grant to the National Institute of Agronomic Research, France. Information was obtained on biosynthesis, purification, and properties of alanine and leucine dehydrogenases from B. subtilis SJ 2. This strain was chosen long ago for its unusual dormancy, and amino acid requirements for germination. The content of enzymes can be varied independently in the vegetative cells but not in the spores (not even in spores of mutant strains). The enzymes were purified extensively and separated physically from each other. They exhibit many similarities except in their substrate specificities. Attempts were made to relate activities of these enzymes to the germination process but details of the latter remain obscure. In electron micrographs a "vesicular stage" of the spore core has been seen. This stage precedes changes in spore refractivity.

2. Sporulation of Food Spoilage Bacteria. Relationship of abnormal morphology (filamentous growth), metabolism of L-arabinose (a pro-sporulation factor), and yield of spores of Clostridium thermosaccharolyticum 3814 is under study. Fluoroacetate at 0.005M represses sporulation but not growth;

less ethanol but more citric acid (or a new compound) are formed than in the absence of the inhibitor.

Vegetative cells have been grown on pyruvate (poor sporulation) and L-arabinose (good sporulation). The cells were disrupted and the hexokinase activities fractionated on DEAE cellulose columns and also by disc electrophoresis. Sporulating cells became long and thick in contrast to bacilli and to some other clostridia which become short and thick during sporulation. This research is being supported by a research grant to the University of Illinois.

3. Control of Microbes in Frozen Vegetables. Twenty-five of 153 line samples from pea and cut bean freezing operations had high bacterial counts (over 50,000 per gram). Most frequent sources of high counts were distributors at freezing tunnel entrance (8 samples) and the intake (4 samples) and discharge (6 samples) of pneumatic conveyors. High counts were found when vegetable particles accumulated on line equipment, especially in locations away from the main part of the processing line. Positive presumptive coliform tests were found in 59 samples. Nine of the line samples had more than 10 colonies per 0.1 gram sample which is the maximum tolerance of some commercial buyers. Aerobacter aerogenes was the dominant coliform isolated. Escherichia coli was recovered from 5 samples but its recovery did not appear to be tied with obvious human contamination nor with high plate counts.

Plate counts from frozen cooked squash ranged from 0.8×10^6 to 3.1×10^6 per gram. These high counts were traced to accumulation of squash solids on the machinery in the line, to inefficient cooling of the cooked product, and to inadequate cleaning of the machinery in the line. In order to meet commercial specifications for low bacterial count in frozen vegetable processing lines, attention must be given to proper cleaning of areas where high counts are found. Production of low count frozen cooked squash requires sanitary construction of lines that eliminate pockets, efficient cooling of the hot puree and thorough and frequent cleaning of lines.

4. Control of Microbes in Dehydrated Vegetables. Sliced onions are dehydrated at moderate temperatures without blanching. Dry and wet cleaning of onions before peeling resulted in small to moderate reductions of total bacterial counts. Washing whole peeled onion, onion slices or onion layers with water or solutions of detergents or bactericidal agents did not cause a major reduction in bacterial count, suggesting that bacteria are imbedded within the onion tissue. Heating sliced onions for 2 minutes at 120° F. reduced counts more than any cold washing treatment. Higher temperatures, longer heating times or use of antibacterial additives further reduced total counts but high temperatures caused loss in onion pungency. Total plate counts increased up to 10-fold when sliced onions were held for 4 to 8 hours before dehydration. This investigation is supported by a research contract to the University of Illinois.

E. Technology--Process and Product Development

1. Removal of Radioactive Fallout. Contract research concerned with the removal of external and internal radioactive materials from fruits and vegetables during processing has been concluded at the National Canners Association in California.

Raw potatoes grown in soil contaminated with radiostrontium were prepared in the form of cubes, shreds, and puree, mixed with water and shaken with ion exchange resin. From 4 to 24 percent of the radioactivity was removed from the solid fraction of the potato. Spray rinsing of strawberries removed only about 30% of external contamination with radiostrontium and 12% of internal contamination. However, when strawberries were blended, diluted with an equal volume of water, and centrifuged, and the supernatant was treated with carbonate to precipitate strontium and calcium, 97% of the radioactivity was removed and 43% of the strawberry material was recovered. There was a 27% loss of ascorbic acid. The final product had a salty taste but would be acceptable under emergency conditions.

Decontamination of potatoes internally contaminated with radiostrontium by treatment with ion exchange resins is not very promising. However, the excellent decontamination of strawberry solubles by precipitation of the strontium with carbonate ion is encouraging.

Publications - USDA and Cooperative Program

RPA 403 - NEW AND IMPROVED FRUIT AND VEGETABLE PRODUCTS

Flavor

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RPA 601 - EXPANSION OF FOREIGN MARKETS FOR U.S. PRODUCTS

Flavor

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Microbiology and Toxicology

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1/ Research supported by P.L. 480 funds.

POTATO UTILIZATION (WESTERN REGION)

Western Utilization Research and Development Division, ARS

USDA and Cooperative Program

Location of Intramural Work	: Scientist Man-Years F.Y. 1968		
	: Research Problem Area :		
	: 403	: 901	: Total
California (Albany)	:	:	:
Technology--Process and Product	:	:	:
Development	: 3.9	: 1.8	: 5.7
Total	: 3.9	: 1.8	: 5.7

Intramural program is supplemented by extramural support representing
 (a) 0.6 SMY's per year at State Agricultural Experiment Stations^{1/},
 (b) 0 SMY's per year at other U.S. institutions, and (c) P.L. 480 funds
 in 2 countries representing 27,736 U.S. dollars equivalent per year.

^{1/} RPA 403 - Chemical Composition and Physical Properties 0.6 SMY.

Problems and Objectives

An historic decline in per capita potato consumption has been reversed by growth of markets for processed products. Consumption has been stabilized at about 110 lbs. since the early 1950's through market growth for processed potatoes. To hold these markets, new and improved products and processes of lower cost must continue to flow from research.

Establishment of large manufacturing plants for potato products has concentrated potato waste which now must be treated to prevent pollution of streams, rivers and lakes. Processes of manufacture must be changed to reduce pollution from potato processing.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Improving color, flavor, texture, and stability of potato products at no net increase in cost.
2. Eliminating the organic matter and lye that contribute to processing plant waste effluents as a result of peeling potatoes for commercial processing.

Progress - USDA and Cooperative Programs

RPA 403 - NEW AND IMPROVED FRUIT AND VEGETABLE PRODUCTS

A. Chemical Composition and Physical Properties

The following investigations provide basic information currently needed to develop potato products with improved color and flavor stability.

1. Lipid Synthesis. In contrast to a previously reported dramatic increase of biosynthetic enzymes in aged potato slices, beta-oxidation of fatty acids, a key step in their degradation, is as fully functional in fresh as in aged potato slices. The key enzyme reaction activated during fatty acid biosynthesis in aging potato slices involves conversion of oleyl CoA to linoleyl CoA. Potato slices convert propionic acid to beta-hydroxy propionic acid or its lactone, rather than succinate, as concluded by other workers.

Studies to determine why some seeds have low lipid contents were initiated. Fatty acid synthetase was found in various subcellular fractions of very young seedlings. This research is conducted under a grant to the University of California at Davis.

2. Autoxidation of Fats. In model systems of unsaturated fatty acids or their esters, a reduction of oxygen tension does not sharply lower the rate of oxidation. Histidine, tryptophane, glycine and alanine had an antioxidant effect and reduced the rate of oxygen absorption. Phenolic antioxidants on the other hand prolonged the induction period but did not

affect the ultimate rate of oxidation once the induction period was over. Copper and manganese ions and, to a lesser extent cobalt and iron, can act as antioxidants at low oxygen pressures. Metal ions are well known to be pro-oxidants for fats exposed to air, but the metallic antioxidant effect occurs when the oxygen concentration of the atmosphere is reduced to a few percent or less. This antioxidant effect was enhanced as the pH of the system was reduced from 7 to 5. At low oxygen pressure reaction products of fat oxidation contained relatively more carbonyl compounds. When model systems were freeze dried a much lower oxygen pressure was required to decrease the rate of oxidation by a given amount. Low oxygen pressure was much more effective in reducing oxidation rate in freeze-dried carrots than in model systems. This research, supported by a P.L. 480 grant to The Swedish Institute for Food Preservation Research, Sweden, has been concluded.

3. Role of Metals in Vegetable Enzyme Action. Enzymes representing different types of metal involvement are investigated: (1) a metal-activated enzyme, 3-phosphoglycerate kinase; (2) two non-oxidase metalloenzymes, carbonic anhydrase and alkaline phosphatase; and (3) two metal-containing oxidases, laccase and tyrosinase. With the first type the major function of the metal ion is to combine with one of the substrates.

Carbonic anhydrase was studied in three aspects: the amino acid side chains in the active site, the sequence of amino acid residues, and certain physical properties (reaction velocities, metal binding, structure in solution). Two histidine residues in human carbonic anhydrase B are in positions close to the active site. The amino acid sequence in the COOH-terminal region was determined for three forms of the enzyme. Similarities are found not for isoenzymes from the same species but rather from kinetically similar forms from different species.

Alkaline phosphatase binds zinc ion at two independent and identical sites. The metal influences the process of association of these subunits, but is not essential for holding them together.

Two cupric ions in laccase are not bound in an identical manner and only one form is rapidly reduced by substrate.

This research is being conducted under a P.L. 480 grant to the University of Gothenburg, Sweden.

B. Flavor (no current research)

C. Color, Texture and Other Quality Factors (no current research)

D. Microbiology and Toxicology (no current research)

E. Technology--Process and Product Development

1. Potato Product Quality. Development of improved processes to control discoloration in processed potatoes is the subject of investigations on

enzymic reactions of potato tissues and effects of bruising on enzyme systems relative to incidence of internal blackspot. Two histochemical methods to identify tyrosine in potato tissue were developed. One is based upon metal chelation by nitrosotyrosine which is formed by the action of nitrous acid. The other method involves a coupling of the products of a diazotization reaction with S-acid. In potatoes tyrosine is of general distribution, slightly concentrated toward the stem end and more concentrated in the inner storage parenchyma than in the cortex. Chlorogenic acid concentrations were highest in the cortex.

Consistently uniform relationships between phenolase and blackspot susceptibility were found after improvement of the analytical methods used. No relationship was found between pre-injury phenol concentration and blackspot susceptibility. Bruising caused a significant increase in total polyphenols and chlorogenic acid. Russet Burbank and Red Pontiac potatoes were bruise-tested for blackspot susceptibility, which was compared with enzyme activity and substrate content. Russet Burbank tissue was relatively resistant to blackspot in November but became more susceptible with prolonged storage.

RPA 901 - ALLEVIATE SOIL, WATER, AND AIR POLLUTION

- A. Chemical Composition and Physical Properties (no current research)
- B. Flavor (no current research)
- C. Color, Texture and Other Quality Factors (no current research)
- D. Microbiology and Toxicology (no current research)
- E. Technology--Process and Product Development

1. Reducing Wastes from Peeling Potatoes. A new potato peeling method has been developed. The method avoids the use of water sprays in removing 90% to 95% of the peel and adhering tissue. Potatoes are sprayed or dipped in a 20% solution of caustic soda for 50 to 100 seconds, drained, and held at room temperature for 5 minutes. Then the potatoes are tumbled in a rotating drum and exposed to radiation from a gas-fired source for 2 to 5 minutes. About half of the peel solids are removed in the drum. The potatoes then go through rotating rolls covered with many flexible rubber fingers. The other half of the peel solids is removed in this step. The remaining 5% of the softened potato tissue is removed in a barrel or brush washer. Adjustment of variables has provided satisfactory peeling of all potatoes likely to be processed. Commercial processors have shown a great interest in this new method since it offers a possibility of reducing costs of waste disposal now required to meet federal and state regulations regarding water quality in streams, rivers, and lakes.

Publications - USDA and Cooperative Program

RPA 403 - NEW AND IMPROVED FRUIT AND VEGETABLE PRODUCTS

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1/ Research supported by P.L. 480 funds.

III. MARKETING AND ECONOMIC RESEARCH

CITRUS AND SUBTROPICAL FRUITS - MARKET QUALITY

Market Quality Research Division, ARS

Handling, Transportation and Storage

USDA and Cooperative Program

Location of Intramural Work	Scientist Man-Years, F.Y. 1968		
	Research Problem Area		Total
	404	501	
Citrus fruit other than limes			
California	3.0		3.0
Texas	0.2		0.2
Florida	4.0	1.0	5.0
Total Citrus	7.2	1.0	8.2
Avocados, mangos, limes and papayas			
Florida	0.5	0.5	1.0
Total sub-tropical fruit:	0.5	0.5	1.0
Total	7.7	1.5	9.2

Intramural program is supplemented by extramural support representing (a) 0.3 SMYs at State Experiment Stations^{1/} and (b) P.L. 480 funds in 3 countries totaling 185,127 U.S. dollars equivalent.

^{1/} RPA 404 0.3

Problems and Objectives

The production and marketing of U.S. citrus fruits, avocados, and mangos is a billion dollar industry. Despite the substantial progress of recent years in bulk handling from the orchard, smaller shipping containers, and improved refrigerated transport, costly losses occur in the markets from decay, physical damage, and rind disorders. Such losses in the market are magnified by the costs of packing, transporting, and selling fruit, some of which is unsuitable for consumer use.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Developing objective quality indices and automated sorting.
2. Reducing decay and functional disorders.
3. Maintaining product quality through mechanized harvest.
4. Extending marketing season through fruit storage.

Progress - USDA and Cooperative Program

RPA 404 - QUALITY MAINTENANCE IN MARKETING FRUITS

A. Quality Maintenance in Storage

1. Controlled atmosphere storage of Florida citrus fruits. Valencia oranges stored in 15% O₂ + 0% CO₂ at 34° F. retained a better flavor than fruit stored in other CA conditions or in air. Fruit stored in CA developed more aging than fruit stored in air. Panel taste tests after 4 months' CA and air storage did not show consistent flavor ratings. Alternaria citri decay was present after storage, although not externally visible, and imparted severe off-flavors to the fruit.

Storage of Marsh grapefruit for 2 to 3 months at 50°, regardless of fungicidal or storage treatment, including CA storage, resulted in 13 to 80% decay.

Unwaxed Temple oranges stored for 5 weeks in 15% O₂ + 5% CO₂ at 40° F. retained excellent flavor but storage for 10 weeks caused a loss of most of the characteristic Temple aroma.

At harvest, Temple orange juice averaged 0.006% ethyl alcohol which increased to 0.114% in unwaxed fruit and 0.203% in waxed fruit after 5 weeks in 5% O₂ at 40° F. Alcohol production during storage was increased by a prestorage application of wax, reduction of O₂ during storage, and length of storage period. (HC-41)

2. Controlled atmosphere storage of Arizona lemons. Arizona lemons stored at 57° F. for 6 months were in marketable condition, with respect to decay, with less than 1% decay. The fruit lost from 10 to 15% in weight

depending upon packinghouse treatment. Lemons stored in 10% oxygen without added CO₂, under the same conditions were greener, showed less weight loss, and were equal in flavor to fruit stored in air. (HC-45)

3. Controlled atmosphere storage of Texas grapefruit. Development of rind pitting in December harvested red grapefruit was affected more by carbon dioxide levels in the atmospheres than by oxygen. Pitting was severe on fruit held in atmospheres in which carbon dioxide was absorbed from the start of CA storage and in atmospheres in which it was reduced to zero from an initial level of 5%. In contrast, fruit from atmospheres in which carbon dioxide was reduced to 2.5% from an initial level of 5% showed only a trace of pitting. Fruit stored immediately in 45° F. air developed more pitting than that cured 3 days at 70° before storage at 45° (1.0% vs. 0.1%).

The incidence of surface browning resembled closely the pattern for rind pitting. It was most prevalent on fruit held in carbon dioxide free atmospheres and occurred the least on fruit from atmospheres with 2.5% carbon dioxide. Fruit stored immediately at 45° F. in air showed more surface browning than fruit cured 3 days at 70° before storage at 45° (19.3% vs. 3.4%).

Decay was more severe in the lots of fruit in which pitting was prevalent. Decay in the individual lots of fruit after 15 weeks ranged from zero (four lots treated with #1991) to 60%. Fruit treated with DuPont #1991 before storage averaged 8.8% decay while the controls showed 28.2%. (HC-35)

Retention of harvesttime peel color was best in fruit held in 2.5% oxygen. Internal quality of all CA lots was acceptable. Peel color was not affected by carbon dioxide levels. (HC-35)

4. Controlled atmosphere storage of Florida avocados, mangos, limes, and papayas. Avocados stored in static and constant flow systems with 1% O₂ + 10% CO₂ at 50° F. developed severe decay. The primary diseases were Colletotrichum, Dothiorella, and possibly Diplodia. The decay developed after 30 days' storage in air, and after 45 and 60 days in CA storage.

Limes stored in 7% O₂ + 10% CO₂ and 5% O₂ + 7% CO₂ at 50° F. retained acceptable peel color after 30-, 45-, and 60-days' storage but juice content was reduced to an unacceptable level. Storage of limes in CA at 40° resulted in severe rind scald which did not develop at 50°. Storage of limes at 50° in atmospheres containing 15% CO₂ resulted in rind injury.

Storing mangos in several CA atmospheres at 50° F., to reduce stem-end decay, resulted in slight to severe chilling injury after 20 days in storage.

Papayas stored for 3 weeks in 1% O₂ + 5% CO₂ at 55° F. developed slight decay. Fruit stored in air and other modified atmospheres developed moderate to severe decay. (HC-38)

5. Citrus volatiles as a measure of storage quality of lemons. Volatiles emanated from green and yellow lemons with and without added ethylene were measured by gas chromatography. Production of total volatiles by lemons was increased by treatment with ethylene. Ethylene-treated green lemons produced more than twice as much total volatiles as ethylene-treated yellow lemons. More than 20 gas chromatographic peaks were detected in volatiles emanating from ethylene-treated green lemons. Nine of these were tentatively identified as α -pinene, camphene, β -pinene, β -myrcene, d-limonene, γ -terpinene, terpinolene, neral, and geranial. (HC-47)

B. Quality Maintenance During Transportation

1. Export shipments of California citrus fruits. Average fruit transit temperatures of 36 orange test shipments were 44° to 57° F.; 9 lemon tests 46° to 55°; and 6 grapefruit tests 47° to 64°. Nearly all biphenyl residues in lemons and grapefruit were below the Common Market tolerance of 70 parts per million. Residues in oranges exceeded tolerance in 3 to 81% of the lots, depending on handling procedures and total temperature pattern. (HC-48)

2. Export shipments of Texas red grapefruit. A containerized shipment of Texas red grapefruit was transported over the highway to Houston and then by special container ship to Rotterdam during the period January 5-27. Cooling of the fruit during transit was slow due primarily to short-circuiting of air from the cooling unit and to a faulty load pattern. Fruit temperatures were satisfactory at market arrival and fruit condition generally satisfactory. (HC-37)

C. Postharvest Physiology

1. Maturation and ripening of avocados. This research under P.L. 480 in Israel has developed information on the identification and action of endogenous growth regulators in avocado tissue. Fruit tissue cultures are grown in artificial media which enables numerous replicated tests of ripening response on sections of mesocarp tissue. (HC-65 (A10-MQ-2))

2. Metabolic changes during storage and ripening of mangos. This P.L. 480 research is underway at the University of Baroda in India. Basic information has been developed on enzyme activity, ethylene synthesis, and carotene increases during postharvest ripening. Some evidence has been developed that susceptibility to chilling injury in mangos can be reduced by surface waxing or gradual increase of exposure to 5° to 10° C. over a period of several days. (HC-63 (A7-MQ-6))

D. Postharvest Disease Control

1. Control of decay of Florida citrus fruits. Five new fungicides were evaluated for control of citrus decay. DuPont #1991, 1-(butylcarbamoyle)-2-benzimidazole carbamic acid, methyl ester, a systemic, (500 ppm) was superior to the other fungicides. Throughout the season this fungicide

controlled all decay except Alternaria on all varieties when applied pre-harvest and prior to inoculation with Penicillium. The fungicide, 5-aceto-8-hydroxy-quinoline-sulfate (1%), was effective but disagreeable to use. Three remaining fungicides were ineffective. Degreening and color-add treatments of Murcott Honey oranges severely increased decay and rind injury without improving the appearance. In CA storage tests, no combination of O₂ or CO₂ which maintained fruit quality prevented decay. (HC-42)

2. Materials affecting germination and growth of decay organisms. The solubilities of five aldehydes which inhibit germination of Penicillium were: valeraldehyde 0.413 M, hexaldehyde 0.113 M, heptaldehyde 0.0094 M, octanal 0.0043 M, and nonanal 0.00056 M. The concentrations ($M \times 10^3$) required to give 50% or more inhibition ranged from 2.5 to 0.04, respectively. As fumigants, valeraldehyde and heptaldehyde were more effective than the other aldehydes tested. (HC-44)

3. Effects of modified atmospheres on growth of decay organisms. Decay rates, sporulation and soilage of lemons and Valencia oranges inoculated with Penicillium digitatum were reduced as oxygen concentration in the storage atmosphere was lowered. Lemons were stored at 56° F. and oranges at 42°. Fungus sporulation was severely restricted at 2% O₂, and fungal growth was only scanty at 1% and absent at 0% O₂. Inoculated fruit removed to air decayed normally. (HC-46)

4. Losses in oranges during marketing. Marketing losses of Navel oranges averaged 4.5% in the New York metropolitan area and almost 7% in the Chicago market. Florida Valencia oranges averaged 4.6 and 5.6% loss, respectively, in the New York and Chicago markets. Losses were caused principally by green mold with smaller losses from Alternaria and physical damage.

5. Antimicrobial action of biphenyl. Research on this P.L. 480 project in Germany has covered physiological responses of a yeast, a bacterium, and 2 fungi to biphenyl and sodium orthophenylphenate. Response to the chemical varied with the organism tested. Neither the yeast nor the bacterium was inhibited by biphenyl but both were slowed by SOPP. Both materials showed specific action on the fungi. The action of biphenyl was fungistatic whereas SOPP was fungicidal. Resistance to both chemicals developed with prolonged exposure. Furthermore, exposure to either chemical ultimately developed resistance to the other. Evidence was developed as to the specific enzyme systems inhibited. (HC-67 (E10-AMS-3))

RPA 501 - IMPROVEMENT OF GRADES AND STANDARDS

1. Degreening Response of Oranges. Studies on the degreening response of oranges in closed chambers indicated that the optimum level of ethylene for maximum color change was between 5 and 10 ppm. No injury appeared to result from ethylene concentrations as high as 2%. Increasing the oxygen level in the chambers from 10 to 50% caused the degreening rate to increase slightly. This response was generally not apparent when ethylene was present. Delaying

effects of low oxygen and temperatures of 70° F. on degreening disappeared rapidly in storage indicating that aeration and higher temperatures may not be needed for good color development. (HC-43)

2. Seasonal Changes in Florida Persian Limes. Limes originating from bloom set in April and harvested 163 days after bloom were approximately 5% higher in juice content than January-set fruit harvested after 163 days. Limes from the January bloom had slightly higher citric acid content and a higher percentage of rind by weight.

Limes harvested in November from 7 rootstocks were held for 3 days at 106°-110° F., and the amount of induced styler-end breakdown ranged from 77 to 98%. Additional fruit harvested the next month and held for 3 days at 100° developed from 0 to 6% styler-end breakdown. (HC-39)

3. The Detection of Additives in Citrus Juices. Continuation of this P.L. 480 project in Spain has developed additional analytical tools for detection of adulterants in citrus fruit juices. Rapid and accurate determination of the carboxylic acids by gas-liquid chromatography has been developed. The finding that the proportion of saccharose to monosaccharides does not change with storage, heat treatment or SO₂ additions provides an additional possible tool for detection of additives. (HC-66 (E25-AMS-5))

Publications - USDA and Cooperative Program

RPA 404 - QUALITY MAINTENANCE IN MARKETING FRUITS AND VEGETABLES

Quality Maintenance in Storage

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Postharvest Physiology

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RPA 501 - IMPROVEMENT OF GRADES AND STANDARDS

Objective Measurement of Quality

Alberola, J., Casas, A., and Primo, E. 1967. Detección de adulteraciones en zumos cítricos. X. Identificación de azúcares en zumos de naranja y sacarosas comerciales por cromatografía gas-liquido. *Agroquímica y Tecnología de Alimentos* 7(4). (E25-AMS-6)

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DECIDUOUS FRUITS AND TREE NUTS - MARKET QUALITY

Market Quality Research Division, ARS

Handling, Transportation, and Storage

USDA and Cooperative Program

Location of Intramural Work	Scientist Man Years F.Y. 1968			
	Research Problem Area			
	404	501	Total	
<u>Deciduous Tree Fruits</u>				
Washington	2.0	1.0		3.0
California	1.0	0		1.0
Maryland (Beltsville)	3.5	2.0		5.5
New Jersey (market)	1.0	0		1.0
Chicago (market)	2.0	0		2.0
Total Deciduous Fruit:	9.5	3.0		12.5
<u>Grapes and Berries</u>				
California	1.5	0		1.5
Maryland (Beltsville)	0.5	0		0.5
North Carolina	0.2	0		0.2
Total Grapes & Berries:	2.2	0		2.2
<u>Dried Fruits</u>				
California (Insects)	3.0	0		3.0
<u>Tree Nuts</u>				
California (Insects)	2.0	0		2.0
Total	16.7	3.0		19.7

Intramural program is supplemented by extramural support representing (a) 0.9 SMYs at State Agricultural Experiment Stations^{1/}, (b) 0.3 SMYs at other U.S. institutions^{2/}.

^{1/} RPA 404 0.9

^{2/} RPA 404 0.3

Problems and Objectives

Deciduous tree fruits, grapes and berries vary in perishability and deteriorate at different rates after harvest. Market losses vary from about 15% in strawberries to an average of only 2 or 3% in pears. Reduction of these losses by half would save millions of dollars, improve market supplies of these essential foods, and decrease retailer and consumer resistance to these perishable items.

Losses of dried fruits and tree nuts caused by stored-product insects in marketing channels averaged \$16.5 million annually during the years 1951-1960 in spite of the \$4 million spent each year on insect control. Improved control treatments that would reduce losses by one-third and the cost of control by 25% would effect an annual savings of over \$6 million by 1980.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Objective measurement and sorting by internal quality.
2. Controlling decay and functional disorders.
3. Storing fruits under optimum environments.
4. Reducing losses caused by stored-product insects.
5. Improving insect control procedures and reducing residues.

Progress - USDA and Cooperative Program

RPA 404 - QUALITY MAINTENANCE IN MARKETING FRUITS AND VEGETABLES

A. Quality Maintenance in Storage

1. Controlled atmosphere effects on apples. Eastern-grown Red Delicious and Golden Delicious apples stored 6 months at 32° F. in atmospheres maintained by a commercial generator were no firmer on removal and in several instances were softer than fruit stored in air. The CA room atmosphere had an average concentration of 5-6% oxygen and 2% carbon dioxide. Under the conditions the oxygen burner was not able to maintain the 2% oxygen level desired for these varieties in a small Mylar-lined room. Leakage of exhaust fumes from the generator into the CA storage is believed to have hastened softening.

Sealed polyethylene carton liners used for shrivel control of Golden Delicious resulted in severe suffocation or low-oxygen injury and winey fruit in the CA room. Perforated film liners with an overlap closure gave good protection from moisture loss in both air and CA storage. (HC-1)

2. Controlled atmosphere storage of western nectarines. The most favorable atmospheres for storing nectarines at 31° F. were those with 2.5 to 5% carbon

dioxide. Increased carbon dioxide with air or with 2.5% oxygen was equally effective for maintaining quality. Dessert quality of the fruit after 8 weeks' storage in atmospheres with carbon dioxide was judged good. Excessive decay developed in all lots after 11 weeks' storage. (HC-56)

3. Controlled atmosphere storage of eastern peaches. Three varieties of peaches stored for 6 and 9 weeks at 32° F. decayed less rapidly in atmospheres of 1% and 21% oxygen with 5% carbon dioxide than in air. Peaches tended to lose their flavor more rapidly in air than in the other atmospheres. Taste panelists preferred peaches of each variety which had been stored in the 1% oxygen-5% carbon dioxide atmosphere to those stored in air or other modified atmospheres. Peaches harvested early in the season at a firmness of 14.5 pounds kept slightly better in all atmospheres than peaches of the same variety harvested at later dates when the firmness had dropped to 12.1 or 10.8 pounds. Graininess, often severe in peaches held 6 and 9 weeks at 32° in air, was markedly reduced in peaches held in atmospheres of 1% or 21% oxygen with 5% carbon dioxide. Peaches held in air at 32° for 6 weeks had a higher respiration rate when transferred to 65° than peaches held in 1% or 21% oxygen with 5% carbon dioxide. (HC-3)

4. Controlled atmosphere storage of strawberries. Strawberries held at reduced oxygen levels (1/2% or less) for 36 hours at 60° F. had less botrytis decay than those kept in air, but off-flavors developed. Most tasters could not distinguish between berries held in 1% O₂ and those held in air but decay was not significantly reduced. These effects were observed immediately after storage and after an additional 24 hours in air at 60° F.

Strawberries exposed to carbon dioxide levels of 20% and 30% at 60° F. for 36 hours developed less decay after an additional 24 hours in air than those held in air the entire time. Tasters preferred the berries that had been in 20 to 30% carbon dioxide to those held in air. (HC-27)

5. Storage of Chinese gooseberry (*Actinidia chinensis*). Fruits of *Actinidia chinensis*, which is becoming a commercial crop in California, were harvested at 5 weekly intervals beginning November 21 and were stored at 32° F. for 4, 8, or 12 weeks. At removal from storage and after 1 or 2 weeks at 60° F. light reflectance, resistance to deformation, soluble solids, and pH were determined on individual fruits. The internal color changed from green to greenish-yellow at the later pickings, and with increased ripening time, but did not change appreciably during storage. Resistance to deformation decreased at the later picking dates, with longer storage time, and with longer ripening time. Soluble solids and pH both increased at the later picking dates, and increased slightly during storage and ripening. Storage life and market quality will be reported later. (HC-68)

6. Storage of new pear varieties. A study was initiated, under cooperative agreement with the University of Maryland, to determine optimum harvest dates, storage environments, and storage period for 2 blight-resistant pear varieties (Magness and Moonglow) now being planted in eastern states. Flesh firmness

and total acids decreased at each of 3 pickings, about 10 days apart. All of the fruits ripened unevenly when ripened immediately after harvest. After 1 month's storage at 32° F. ripening within a lot was quite uniform. Decay was not serious after 2 months' storage, but rather serious at the end of 3 months. Internal breakdown developed after 3 months' storage and did not seem to be related to time of harvest. The fresh and processed quality of sound fruit was satisfactory after 3 months' storage at 32° and ripening at 65°. (HC-58)

B. Quality Maintenance During Transportation

1. Air shipment of California strawberries. Domestic air shipping tests. Strawberry temperatures averaged about 46° F. in pallets with sealed fiber-board covers and about 49° F. in open pallets in air shipping tests made during the spring, summer, and fall seasons. Relative humidity in the cabin of the jet freighter averaged about 3%. Atmospheres in the sealed pallet covers with added carbon dioxide averaged about 12% CO₂ and 15% O₂ in covers with a fold-strap seal and 8% CO₂ and 16% O₂ in covers with a taped seal. Decay averaged about 5% of berries in the sealed pallets and 8% of berries in the open pallets after a holding period of 1 day at 60° F. at the market.

Export tests. Strawberries shipped from Southern California to London by jet airfreighter were about 21 hours in transit at temperatures ranging from 47° to 62° F. Fruit temperatures in an insulated container increased only about 5°, while the temperature of fruit carried open in the cabin of the plane increased 15°. Atmospheres in sealed pallet covers with added CO₂ had CO₂ levels near 15%. Practically no decay developed in this lot of berries, but over twice as many soft, overripe berries occurred in fruit carried outside the container. (HC-27)

C. Postharvest Physiology

1. Scald control for eastern apples. The extensive commercial use of non-sealed polyethylene liners to control shrivel of Golden Delicious apples has resulted in more scald development following long storage. The antioxidant ethoxyquin ("Stop-Scald") used as a 10-second prestorage dip in 70° F. water at 2700 ppm gave excellent control of scald on Golden Delicious apples with no skin injury in 3 tests. A 20-second dip in 130° water gave good control in only 1 of the 3 tests with Golden Delicious. Scald development on Golden Delicious in non-sealed polyethylene was appreciably less in CA than in air storage in only 1 of 3 tests.

Scald on Red Delicious and Stayman varieties of the 1967 crop was light, possibly due to the cool weather prior to harvest. Use of CA storage, rather than conventional air storage, did not consistently reduce scald development. Both of the approved chemical dip treatments (2000 ppm diphenylamine and 2700 ppm ethoxyquin) gave good scald protection but diphenylamine was better for the Delicious variety. In 2 of 3 tests, a 5-minute dip in 120° F. water before storage gave better scald control, without injury, than use of

diphenylamine or ethoxyquin. Treatment for 20 seconds in 130° water caused skin injury on Delicious. Good control of scald on Stayman apples, in this light scald season, was obtained by treatment 2 weeks after harvest with either diphenylamine, ethoxyquin, or 20 to 30 seconds in 130° water. (HC-2)

2. Scald control for western apples and pears. Less storage scald developed on commercially waxed Starking Delicious apples than on untreated fruit. DPA applied in wax or as a spray on the fruit just before waxing produced no further scald reduction. DPA wraps on waxed fruit reduced scald about the same amount as a DPA spray applied immediately after harvest.

Experimentally waxed fruit developed slightly more scald than checks, and almost twice as much as commercially waxed fruit. The main difference in the two methods of application was the use of heat to dry the fruit in the commercial operation. This suggests partial control of scald by heating the fruit.

Submersion of Anjou pears in water at 125° and 130° for 3 minutes or 135° for 2 minutes controlled both scald and blue mold rot.

Ethoxyquin applied in sprays, wraps, or waxes, controlled scald on Golden Delicious apples and Anjou pears. Ethoxyquin applied as a spray just before waxing reduced scald on Anjou pears. (HC-54)

3. Effects of preharvest environment on postharvest quality of apples.
Controlled bloom. Delicious apples from trees induced to bloom by artificial cooling or warming at 4 different dates were harvested at 135, 145, and 155 days from their respective blooms. After 7 to 8 months' storage, the firmest fruit and that with the highest soluble solids was from the earliest bloom and these values decreased in fruit from each later bloom date. The titratable acidity followed the same pattern at harvest but after storage, the differences in acid content were small.

Fruit harvested at 155 days from the early blooms developed storage scald while water core was found in the fruit from the 2 later blooms.

Shape of the fruit was more elongated from the two early blooms, but external color was better on fruit from the last two bloom dates.

Fruits harvested at 145 days from bloom regardless of bloom date, were usually rated best in an organoleptic evaluation. The exception was the latest bloom date where fruit harvested at 135 days was rated best.

Natural bloom. General indications are that Red Delicious from orchards which bloomed after the middle of May developed better color in the same period from bloom than fruit from earlier orchards. Storage scald development was not related to bloom date. Fruits from late blooming orchards, harvested 155 days from bloom, were the only ones with any water core. Soluble solids varied by orchard although all fruit from the late orchards had high solids.

Soluble solids and acid in Golden Delicious varied by orchard and may be influenced more by nutrition than environmental factors. Fruits from the late-blooming orchards were relatively high in solids and acid and fruit from these orchards harvested 155 days from bloom were slightly firmer than those from early bloom. However, breakdown developed in this fruit and not in that from the early blooming orchards. (HC-55)

4. Effects of preharvest environment on postharvest quality of pears. This work done in the Hood River Valley under cooperative agreement with the Oregon Experiment Station showed clearly that Bartlett pears maturing on artificially cooled limbs softened and colored prematurely as compared with pears on limbs at ambient temperatures. During the 7- to 21-day preharvest cooling period citric acid decreased markedly in the cooled pears, but increased in the controls. Both quantitative and qualitative changes occurred in amino acids in the cooled pears and respiratory activity was higher in the cooled fruit. The normal pattern of metabolism during maturation was substantially changed by maintaining day temperatures at 60-65° F. and night temperatures at 36.4° as compared with fruit exposed to ambient temperature. (HC-57A)

5. Effects of pesticides on storage quality. Research under this P.L. 480 project in Finland has shown that postharvest application of the growth regulator CIPC resulted in significant increases in reducing sugar in plums and reduction of B-carotene content in tomatoes ripened after harvest. Additional tests, both preharvest and postharvest, will be made with these and other fresh fruits to determine the physiological basis for these effects. (SP-43
(E8-AMS-6(a)))

D. Postharvest Disease Control

1. Heat treatment for table grapes. Emperor grapes that had been treated with hot water (115-118° F.) for 10 minutes before storage had about 30% as much decay as non-heated lots after 10 weeks in storage at 32° F. Fungicides (manzate, botran, and thiabendazole) applied as a dip reduced decay an additional 10 to 15%. Without heat, the fungicide treated lots had 60 to 70% as much decay as the non-treated lots. The grapes were not injured by the treatments, but none of the treatments were as effective as the standard sulfur dioxide fumigation. (HC-28)

2. Decay control for strawberries. The "half warming" times of strawberries decrease with increasing air flows at least up to 20 cfm/lb. of fruit. More consistent and uniform reduction in decay with moist heat has occurred at high air flows. With more rapid heating at the higher air flows, exposure time must be reduced to avoid injury. At 107-108° F. and low flow rates (4-6 cfm/lb. of fruit), 40-45 minutes exposure was required for effective decay control; at high flow rates (15-20 cfm/lb. of fruit), 25-30 minutes exposure was equally effective. Very ripe berries seem to be more susceptible to heat injury than berries at optimum shipping maturity. Decay was not controlled as well on very ripe fruit as on less ripe fruit. During simulated air shipment (36 hr. at 60° F. ambient), the most effective postharvest treatment for strawberries was to (a) maintain berry temperature at 35° F. Next

in order of effectiveness were: (b) Heat pasteurization (108° F. for 30 min.), (c) maintaining a 1% O₂ atmosphere, (d) 20% CO₂, (e) a 0.5% DHA dip for 15 seconds, and (f) a 2500 ppm Captan dip for 15 seconds. All the above treated berries had less decay than an untreated check held at ambient temperature.

In 6 tests with field-infected strawberries, postharvest dip treatments with Dupont Chemical 1991 and Geigy Chemical 20072 failed to reduce decay (mostly botrytis) during 4 days at 60° F. Exposure to 110° F. air for 30 or 60 minutes with high relative humidity reduced decay of these berries by over 50%. Respiration rates of the heated berries was somewhat lower than that of non-heated ones. (HC-28)

3. Heat treatment of peaches. Peaches inoculated with Monilinia fructicola and non-inoculated peaches heated in 125° F. water for 2½ minutes developed considerably less brown rot during 6 and 9 weeks' storage in CA at 32° and during ripening in air at 65° than comparable non-heated peaches. Heat-treated Red Globe peaches sprayed with Captan shortly before harvest developed severe black to tan mottle. The injury was more pronounced after 9 weeks than after 6 weeks of storage. Heat-treated Redskin peaches which were not sprayed with Captan before harvest did not show severe heat injury until after 9 weeks of storage. Heat injury was less severe on peaches stored in air than those stored in 1 or 21% oxygen with 5% carbon dioxide.

Electron microscopic studies showed that the internal content of germinated Rhizopus stolonifer and Monilinia fructicola spores are severely damaged by heating the spore in 125° F. broth for 2½ minutes. The nuclei of heated germinated Rhizopus spores are either destroyed or broken into fragments. The heat treatment, though preventing further elongation of germ tubes of Monilinia spores, did not destroy the nuclei in the spore or their germ tubes.

4. Heat treatment of figs. Surface mold and rhizopus rot of Black Mission figs were greatly reduced by pasteurization in moist hot air at 116° F. for 30 to 60 minutes. After 3 days at 65° F., about 1/5 as much mold and decay developed in treated as in the untreated lots. In taste tests, most tasters could not distinguish between heated and non-heated figs. Pasteurization is most effective on figs that are not fully ripe.

Rhizopus rot and surface mold of Kadota figs were reduced by 1 hour exposure to moist air to a temperature of about 115° F., which did not change the flavor or texture of the fruit. Development of decay was delayed for 1 or 2 days, but was not prevented by the treatment. (HC-28)

5. Effects of atmosphere modification on growth of certain fungi. The mycelial growth of 5 commonly occurring decay fungi decreased linearly with decreasing O₂ concentrations below 4%. At 4% O₂ growth of Botrytis cinerea, Cladosporium herbarum, Alternaria tenuis, and Fusarium roseum was 44-55% of that in air, and that of Rhizopus stolonifer was 85% of that in air.

When Botrytis, Alternaria, Fusarium, and Cladosporium were grown in atmospheres of 2% O₂, growth was stimulated by the addition of low concentrations of CO₂. Peak stimulation occurred with the addition of 4% CO₂ for Alternaria and Fusarium, 8% CO₂ for Botrytis, and 16% CO₂ for Cladosporium. CO₂ at all concentrations depressed the growth of Rhizopus stolonifer.

When O₂ levels were normal (20% O₂), the growth of all fungi tested except Fusarium decreased linearly with increasing CO₂ and 50% inhibition occurred at 20-23% CO₂. Fusarium was stimulated by up to 20% CO₂ and 50% inhibition occurred at 45% CO₂.

Germination of Rhizopus and Cladosporium spores was inhibited by about 50% CO₂ in atmospheres of 1% O₂. Germination of Alternaria, Botrytis, and Fusarium spores was significantly inhibited only at atmospheres of 0.25% O₂ or less.

High CO₂ atmospheres also inhibited spore germination, with 50% inhibition of Botrytis and Cladosporium occurring at 16% CO₂, and of Rhizopus at 2% CO₂. Germination of Alternaria and Fusarium was only slightly inhibited by 32% CO₂. (HC-30)

6. Radiation effects on pathogenicity of fungi. Virulence of auxotrophic mutants of Penicillium expansum is related to the presence and availability of growth promoting amino acids in the host tissue and/or to the production by the fungus of anti inhibitors to overcome the host's defense mechanism. An avirulent beige colored, acriflavine resistant mutant of P. expansum which required leucine and nicotinic acid for growth was obtained after ultra-violet light radiation treatments. In apple tissue, reversions for the leucine requirement resulted in the restoration of virulence. In vitro, methionine inhibited the growth of the mutant when the molar concentration ratio of methionine to leucine was at least $8.5 \times 10^{-4}M$: $2.3 \times 10^{-4}M$ respectively. None of the methionine analogs tested reversed the inhibition. In apple fruit, however, growth and virulence of this mutant was obtained in decreasing amounts by the addition of either leucine, ethionine, methionine, sulfoximine, arginine or after mechanical bruising.

Auxotrophic and streptomycin resistant mutants of Erwinia carotovora were produced either by UV treatment (450 ergs/mm^2) or by the mutagen N-methyl 1 N-nitro-N-nitrosoguanidine (MNNG-250 ppm for 30 min.). No mutants were obtained from among 6,000 survivors of UV treatment that had lost their ability to produce pectolytic enzymes. This would indicate the presence of more than one gene locus controlling the production of more than one pectolytic enzyme. (HC-22)

7. Composition of blueberries as related to postharvest decay. Tests with blueberries harvested from two locations at weekly intervals again showed that varieties high in acid develop less decay. Sugar contents may have a minor influence. Analysis of the 1967 data produced a correlation of +.892 between percent decay and soluble solids:acid ratios. Postharvest decay in

Wolcott and Jersey blueberries was associated with large size and with high light transmittance difference meter readings within a size. (HC-51)

8. Proteolytic enzymes in death of fruit tissues. Botrytis cinerea and Botryosphaeria ribis did not produce a detectable protease in infected apple tissue when tested by the casein digestion method (measurement of tyrosine liberated). However, a more sensitive viscosity assay (gelatin substrate) did reveal protease activity in diseased apple tissue infected with each of these fungi.

Limited efforts to improve the methods of extracting diseased tissue were made. Vacuum infiltrating polyethylene glycol, a phenol-complexing agent, into the diseased tissue did not improve enzyme recovery in limited attempts.

A conidial isolate of Glomerella cingulata produced an active protease in diseased apple. Activity was strong in both the casein hydrolysis and gelatin viscosity assays. (HC-17)

9. Identification of market diseases. Apples. Moldy carpels and core rots have been observed in Red Delicious apples from Virginia and Washington. Apples from Virginia were more affected than those from Washington. Eighty one percent of 485 fungal isolates recovered from moldy cores were identified as Alternaria tenuis. In addition the following fungi were isolated: Leptosphaeria, Rhizopus, Cladosporium, Fusarium, Penicillium, Tricothecium, Pleospora, and Hormodendron sp. A relationship between open core and decay was noted. (HC-18 & 23)

10. Losses in fruits during marketing. Apples. Red Delicious apples from the Northwest averaged about 4% loss through consumer levels in the New York market and 14% in the Chicago market. Bruise damage accounted for most of the loss. Appalachian Delicious apples averaged slightly less market loss in the New York City market.

Peaches. Brown rot and bruising caused most of the losses in Southeastern peaches. Losses through the consumer level averaged more than 15 and 24% respectively in the New York and Chicago markets.

Strawberries. Over a 6-month marketing period marketing losses in California strawberries averaged more than 25% in both the New York and Chicago markets. Decay and physical damage caused most of the loss. During a 1-month marketing period losses in Southeastern strawberries averaged 22% at wholesale and retail and an additional 16% at the consumer level. Losses were principally from gray mold. (HC-19 & 24)

E. Prevention of Insect Infestation

1. Biology, ecology and physiology. Biology, ecology and behavior studies of Oryzaephilus surinamensis and O. mercator showed that temperature and food affected their rate of development, egg production, life span, preoviposition and oviposition periods. (SP-46)

Malathion did not alter the time of day at which the Indian-meal moth deposited the greatest number of eggs. Malathion-treated adults deposited greatest number of eggs on the 1st day as opposed to the 3rd day for untreated moths. Viability and greatest number of eggs produced was less for treated moths. Temperature fluctuations from 24 to 30° C. in phase with normal timing of light did not alter circadian egg production of treated or untreated moths, as was found at 27° C. A 12-hour reversal of the temperature fluctuations during a normal light cycle caused in untreated moths a secondary peak of egg production 6 hours earlier than the normal peak. A combination of malathion and reversed temperature cycle caused a 12-hour delay in the peak oviposition time on the first day. (SP-47)

Various species of nitidulid beetles have been collected from the following areas: Alabama, Arizona, California, Florida, Georgia, Hawaii, Indiana, Michigan, Mississippi, Nevada, Ohio and Mexico. Laboratory cultures have been established of Carpophilus lugubris, C. corticinus, C. californicus, C. freeman, C. marginellus, C. mutilatus, C. hemipterus, C. obsoletus, C. dimidiatus, Haptoncus luteolus, Urophorus humeralis, Stelidota geminata, Colopterus sp. Samples of the immature stages of the various species have been preserved, and microslide specimens for morphological study have been prepared. (SP-37 (A9710))

Oxygen uptake in 3 mite species increases from egg through the adult stage. Resting stages have uptake only little smaller than that of previous active stage. Uptake of mobile hypopus is smaller than that of resting protonymph.

Three species of mites common under field conditions developed with fungi as sole food, but 2 other species could not. Two of the 5 species developed on medicinal herbs, but flour mites did not develop on sterilized herbs in the laboratory. (SP-44 (E21-MQ-1(a)))

2. Improved insecticidal control. Residues on raisins dried on malathion-treated trays were influenced by maturity of grapes and temperature. More mature grapes had lower residues and raisins that had dried during warmer weather had higher residues.--Regular dosages of pyrethrins thermal aerosols did not effectively control insects in wineries.--Fifty percent of 426 dried fruit packages used by the industry became infested after 3 months' exposure to large numbers of insects.--Packaged raisins coated with vegetable oil had 47% less infestation than unoiled raisins.--Aluminum phosphide at the rate of 5 tablets per 1,000 cu. ft. was effective against insects in commercially stocked raisins. (SP-46)

Malathion residues of less than 8 ppm protected shelled almonds from beetle damage for one year. (SP-47)

RPA 501 - IMPROVEMENT OF GRADES AND STANDARDS

1. Eastern Apples. During the 1967-68 season the taste panel scored low chlorophyll apples as sorted by wavelengths Δ O.D. (700-740 nm), significantly

higher in sweetness and flavor than apples high in chlorophyll. These results agree with those obtained in 1966-67. However, quality differences for categories sorted by wavelength Δ O.D. (580-640 nm) in 1967-68 were not as large as in 1966-67.

Although average acidity for all apples measured in 1967-68 was about the same at harvest, significant differences in acidity levels between chlorophyll-sorted categories became apparent in controlled atmosphere (CA) storage, but not in conventional storage. Overall acid loss was less in CA-stored apples. (HC-11)

2. Western Apples. Golden Delicious apples harvested on several dates and treated with 1000, 5000, and 20,000 rad of gamma radiation showed no effect of the treatment when examined in January. However, in late June, fruit harvested at 145 days from bloom was slightly but consistently firmer than the check fruit. The differences in firmness after long storage were not found in fruit harvested at 160 days from bloom. Scald on Golden Delicious was decreased in proportion to the amount of gamma radiation applied with very little scald present on fruit treated with 20,000 rads.

Preliminary examinations of the 1967-68 data indicate that the chlorophyll content of Golden and Red Delicious is related to nitrogen nutrition of the tree. Higher leaf potassium values were generally related to higher acid content of the fruit. (HC-53)

3. Red Tart Cherries. The amount of scald in the canned samples of cherries from lots held in soak tanks with 1 or 11 ppm oxygen was often much higher than the scald in frozen samples from the same lots. There was no apparent consistency in the amount of scald in the fresh, canned, and frozen fruits. The relation between oxygen or temperature of the soak water and subsequent scald development in the processed fruit was poor. Increased oxygen which was expected to decrease scald actually increased symptoms resembling scald. This suggests that the discrepancy may be due to the development of oxidative browning which was observed in one very high oxygen treatment. (Exploratory)

Publications - USDA and Cooperative Program

RPA 404 - QUALITY MAINTENANCE IN MARKETING FRUITS AND VEGETABLES

Quality Maintenance in Storage

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RPA 501 - IMPROVEMENT OF GRADES AND STANDARDS

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VEGETABLES - MARKET QUALITY

Market Quality Research Division, ARS

Handling, Transportation, and Storage

USDA and Cooperative Program

Location of Intramural Work	Scientist Man Years F.Y. 1968		
	Research Problem Area		Total
	404	501	
California	2.5	0	2.5
Florida	1.0	0	1.0
North Carolina	0.8	0	0.8
New Jersey	2.0	0	2.0
Illinois	1.0	0	1.0
Maryland (Beltsville)	3.0	1.0	4.0
Total	10.3	1.0	11.3

Intramural program is supplemented by extramural support representing 0.3 SMY at a State Agricultural Experiment Station.^{1/}

^{1/} RPA 404 0.3

Problems and Objectives

Fresh vegetables are essential to good nutrition, but most are highly perishable and during much of the year are marketed at great distances from the area of production. Losses during marketing are particularly heavy for leafy vegetables and tomatoes. Of some 70,000 carlots of head lettuce shipped from western states each year, losses during transit, handling, and retailing are estimated at more than 21 million dollars. Losses during tomato marketing are about the same and millions of dollars worth of melons, sweetpotatoes and celery end up in distress sales or as garbage.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Maintaining quality of mechanically harvested products.
2. Providing optimum transit environment for each commodity.
3. Making objective measurements and sorting by internal quality.
4. Accurate sampling of products in bulk bins.
5. Understanding postharvest physiology and pathology.

RPA 404 - QUALITY MAINTENANCE IN MARKETING FRUITS AND VEGETABLES

A. Quality Maintenance in Handling and Packaging

1. Ripening of machine-harvested tomatoes for processing. Field-run lots of mature-green to light pink fruits from machine-harvested lots required about 10 days at 68° F. or 8 days at 77° for an 80 to 90% yield of ripe fruits. The machine-harvested fruits ripened faster than hand-harvested fruits from the same fields. Ethylene production by individual fruits was not influenced by method of harvest, but only by stage of ripeness of the fruits. Exposure of unripe fruits to 200 to 400 ppm ethylene for 2 to 3 days hastened ripening. Decay during ripening varied greatly, but averaged about 13%. (Exploratory)
2. Effect of temperature and kind of light source on ripening. Study of tomato temperatures during ripening under several incandescent and fluorescent light sources indicated that fruit temperatures varied as much as 1.6° F. in one test and 0.6° in another. In the first test fruit ripened under continuous incandescent with highest a_L/b_L ratios was also the highest in fruit temperature. Another experiment was conducted to determine the heat rise in red and green fruit under various light sources, including Gro-Lux lamps. Differences in temperature rise of red compared to green fruit under three light sources appear to be slight except for Gro-Lux lamps. Greater differences occurred in temperature rise due to light source. (HC-13)

B. Quality Maintenance in Storage

1. Sweetpotatoes. Large differences in weight and volume losses among varieties developed in storage with considerable consistency for each variety

when compared with the previous year. Pithiness was directly correlated with rapid weight loss, small volume loss, low tissue specific gravity, and high respiration rate. The equation developed in the previous year for predicting pithiness was accurate to within 1 ml. per 100 ml. of volume. Late planting (June) reduced intercellular space at harvest below amounts in earlier plantings. Roots stored at 80° F. did not have as desirable a texture or flavor after 6 or 12 weeks when baked as roots stored at 60°. After 12 weeks of storage pithiness was significantly greater at 80° than at 60° and taste panelists began to note objections associated with pithiness which measured 13.7 ml. per 100 ml. of volume. (HC-52)

2. Storage of mature-green tomatoes in controlled atmospheres. Mature-green tomatoes stored well for 3 weeks at 55° F. in air and several modified atmospheres. However, after 6 weeks' storage, tomatoes in air were almost totally decayed but only 4% were decayed in atmospheres with 3% oxygen with or without 5% carbon dioxide. After one additional week for ripening in air at 65°, the decay in the 3%-oxygen lots had increased to approximately 12%. Decay after 9 weeks at 55° was excessive in all atmospheres tested. Flavor was not impaired in tomatoes held at 55° in atmospheres of 3% oxygen, with or without 5% carbon dioxide, or in air, for periods up to 6 weeks. Some injury was observed in tomatoes from the low-oxygen atmospheres after 6 and 9 weeks' storage at 55° when 5% carbon dioxide was present. The injury was confined to the surface of the fruits.

Mature-green tomatoes ripened almost completely in 3 weeks in air at 55° F., whereas, they remained predominantly green for 6 weeks in atmospheres with 3% oxygen. The addition of 5% carbon dioxide to the low-oxygen atmosphere further retarded ripening. After removal from the low-oxygen atmospheres, tomatoes ripened to a good red color in air at 65°.

A 2-minute dip in 130° F. water after storage in modified atmospheres at 55° did not consistently reduce decay in tomatoes during ripening. (HC-6)

3. Storage of vegetables in reduced atmospheric pressure. Replicated experiments showed that ripening of mature-green tomatoes in atmospheric gas at 65° F. was delayed by decreases in total hypobaric pressure. Decreases in ripening rate were less apparent at hypobaric pressures when oxygen partial pressures were held constant. Treatment effects were objectively measured. Hypobaric storage equipment was improved and storage principles developed. The work indicates that hypobaric vapor pressures will require auxiliary control. (HC-9)

4. Kale. Unwashed bulk kale in bushel baskets with package ice held up well for 4 to 5 weeks at 32° F. or for 1 to 2 weeks at 40°. Kale prepackaged from these bushel baskets into cellophane bags kept well 2 days when placed immediately at 70° or 1 day at 70° after storage. Unwashed kale prepackaged commercially in perforated cellophane bags held up well for 3 weeks at 32° with a shelf life of 1 day at 70°. Unwashed kale kept for 2 weeks at 40° or 5 days at 50° but had no shelf life at 70° following storage. Washing reduced the

storage life of both bulk and prepackaged kale to one half that of unwashed kale. Yellowing of leaves and bacterial soft rot were the main causes of deterioration.

Heat production (respiration) of kale in B.t.u. per ton per day averaged: 5,000 at 32° F.; 8,900 at 40°; 17,100 at 50°; 34,100 at 60°; and 50,900 at 70°. Cutting kale leaves into strips increased respiration rates about 20%. (HC-5)

5. Lima beans. Lima bean pods were injured (rusty-brown spotting and discoloration) by storage for 1 week at temperatures of 32°, 36°, 40° and 45° F. and more seriously by 2 weeks' storage. The brown pod discoloration became much more severe after a day at 70° following refrigerated storage. Fresh lima beans stored even 1 week at 32° to 45° have almost no shelf life on removal because of pod discoloration. (HC-5)

6. Modified atmosphere effects on miscellaneous vegetables. (Cooperative with University of California) Celery. When held for from 4 to 16 days in several combinations of oxygen, carbon dioxide and nitrogen, celery was only slightly benefited by 2 to 4% O₂ and injured by CO₂ above 5%. Optimum refrigeration was of more value for celery than atmosphere modification.

Mushrooms. Atmospheres of 1 to 2% O₂ and 10 to 15% CO₂ slowed cap opening and maintained product appearance compared with air at comparable temperature. Oxygen concentrations below 1% were harmful after 8 days.

Sweet corn. Benefits in retention of sweetness and fresh appearance were obtained under refrigeration with 2 to 4% O₂ and up to 20% CO₂. Off flavors developed in corn held at 1% O₂ or above 20% CO₂.

Cantaloups. Three holding tests with cantaloups indicated favorable response to reduced oxygen and increased carbon dioxide. Atmospheres of 2% O₂ and CO₂ up to 20% were promising for simulated transit periods under refrigeration.

Green peppers. One experiment indicated that development of red color can be retarded by holding in low oxygen but shelf life was not extended.

Garlic. Beneficial effects from storage in 4% oxygen were indicated for long term storage at optimum temperatures. (HC-60A)

C. Quality Maintenance During Transportation

1. Lettuce. Average lettuce temperatures during transit were 36° F. in forced-circulation, nitrogen-refrigerated (N) trailers (Polarstream) and 39° in mechanically-refrigerated (MR) trailers. Average temperatures at various positions within the loads varied by 2° to 3° in both types of trailers, but some freezing occurred in the coldest positions of the N trailers.

Market quality of lettuce from both types of trailers was generally satisfactory at destination. Butt discoloration was slightly less severe and decay was less prevalent at time of arrival in lettuce shipped in the N trailers than that shipped in the MR trailers. The low-oxygen atmosphere in the N trailers also reduced russet spotting.

Paired-car and paired-truck rail trailer shipments of lettuce have been made to compare the quality of lettuce shipped under mechanical refrigeration in air and modified atmospheres with reduced oxygen levels and added carbon monoxide. These tests are still in progress. (HC-32)

2. Celery. Two paired-car test shipments with California celery were made to terminal markets to compare transit temperatures, container damage, and product quality in two different load patterns. The conventional, crosswise, on edge load is being compared with the lengthwise, on edge load. The tests are still in progress. (Exploratory)

D. Postharvest Physiology

1. Effects of field environment on market quality of cantaloups. White-washing the surface of on-the-vine cantaloups exposed to the sun prevented excessive heating of the flesh. The painted fruits and those with a normal cover of leaves reached a maximum of 100° F. 1-2 mm below the surface, whereas untreated fruits exposed to the sun reached 127° F. when the air temperature was 102°. Flesh and cavity temperatures responded similarly, although their temperatures were 5° and 8° lower, respectively, than surface temperatures.

The top half of the melons that were painted white or covered by leaves contained 10% soluble solids at harvest while those that were exposed to the sun and not white-washed contained 9% (difference significant at 95% probability level). No significant difference in soluble solids existed in the lower half of the fruits.

Surface mold and rhizopus rot were more severe in the unpainted, exposed melons than in the others during postharvest holding. (HC-29)

2. Translucent scales of onions. In a 7-day holding test at room temperature with a commercial shipment of Michigan onions, there was a significant reduction in damage by translucent or watery scales with many bulbs decreasing from the moderate and severe injury categories to the slight. The pattern was similar though less pronounced after 38° F. storage.

In a test with translucent or watery scale condition artificially induced by bruising, significant increases occurred in the recovered and slight injury categories and a significant decrease in the moderate and severe injury categories following an 8-week storage period at 38° F. No appreciable benefit was noted from storing treated onions for 2 weeks at 60° prior to storage at 38° for an additional 6 weeks. Storage breakdown did not appear to be significantly affected by the bruising treatment. (HC-20)

E. Postharvest Disease Control

1. Onions. A 2-week curing period in simulated bulk storage with forced heated air at 98° F. and above reduced botrytis neck rot from about 29% in lots without curing to as low as 3% in some curing treatments. Lack of uniform temperatures throughout the pile resulted in some bacterial soft rot development. Weight losses in storage averaged 6.6% for the heat-treated lots and 5.9% for the non-heated.

Cut necks of onions dusted with either 2-aminobutane or ortho 5871, and then inoculated with *Botrytis* spores developed 4.2 and 5.6% decay, respectively, in storage. Untreated lots developed 24% decay. Other chemical treatments were not effective.

Freshly harvested onions, artificially inoculated with *Botrytis allii* spores after they were sprayed in the field with the experimental systemic fungicide DuPont #1991, developed 66% decay after 3 months in storage. When the systemic was applied to the harvested bulbs before inoculation, decay in storage was reduced to 6%. (HC-16)

2. Cantaloups. Treatment of cantaloups with hot water at 135° F. for 30 seconds effectively reduced decay from fusarium rot. Equivalent results were obtained by dipping in a solution of 750 ppm active chlorine or in ziram at 3250. The three best treatments were 250 ppm thiabendazole, 3250 ppm maneb + zinc and 3250 ppm captan. Heat, having the advantage of being residue-free, shows promise as an effective and practical postharvest treatment for control of decay in cantaloups. (Exploratory)

3. Market diseases of Puerto Rican vegetables. The following crops have been investigated for market disorders as they arrive on the Chicago market: apio (10), boniato (16), calabaza (15), chayote (1), ginger (7), malanga (13), ñame (26), yautia (12), and yuca (10). The figure in parentheses indicates the number of organisms isolated from diseased areas that were pathogenic when inoculated into the commodity.

Neither hot water treatments nor chlorine rinses were effective in reducing wastage of these commodities. However, the results of pilot studies, using 1% SOPP and Botran or 1% SOPP and Botran plus a wax coating indicate that these methods may be beneficial in reducing decay of the root crops during storage and transit. (HC-21)

4. Effects of chlorine on vegetable decay organisms. A method was developed for determining the populations of the bacterium *Erwinia carotovora*, which causes bacterial soft rot of vegetables. Populations of 16,000,000 soft rot bacteria per ml of dump-tank and washer water were recorded in a commercial carrot plant and 300,000 per ml in celery hydrocooler water.

The fungicidal effects of the surfactants dodecylbenzene sulfonate (Santomerse F85), alkylphenol ethylene oxide (Sterox NJ), and Octyl polyethoxy ethanol (Triton X100) increased as their concentration increased from 1 to

100 ppm. Polyoxyethylene sorbitan monooleate (Tween 80) had no fungicidal effect. Alternaria tenuis was the test fungus. (HC-40)

5. Role of enzymes in death of vegetable tissue. Potassium nitrate (0.5 M) was more effective in protecting sweetpotato than white potato from maceration by crude enzyme extracted from Rhizopus-rotted sweetpotatoes. The salt provided no protection to white potato tissue and only slight protection to sweetpotato tissue immersed in macerating enzymes from bacterial soft-rotted potatoes.

Protease activity of juice expressed from bacterial soft-rotted potatoes varied with the substrate used and was not correlated with the amount of soft rot. No correlation existed between the ability of a bacterium to reduce triphenyltetrazolium and its soft-rotting ability. No evidence was found to suggest that extracellular phospholipidases are involved in pathogenesis of potato tissue by soft rot bacteria. (HC-10)

6. Identification of market diseases of vegetables. Horseradish. Roots of horseradish stored commercially for 10 months had viable microsclerotia of Verticillium albo-atrum (Verticillium wilt) throughout the vascular ring. The severity of infection and the lack of symptoms at harvest suggest that the fungus proliferates in storage.

Sweet corn. Southern corn leaf blight, caused by the imperfect stage of Cochliobolus heterostrophis, was reported for the first time to be a problem on sweet corn ears on the market. Temperatures between 75° and 95° were favorable for the rapid growth of the pathogen.

Green onions. A hitherto undescribed basal rot of early green onions was found in rail shipments from Arizona. The lesions were of various sizes in the outer scales, gray-black, and had a firm texture and definite margins. Some softening and sloughing off of the infected outer scales was observed. The causal agent, Botrytis allii, is the same as that causing gray mold or neck rot of mature dry onions.

Lettuce. A new market disease of lettuce, referred to by the trade as "San Pablo Blight," is different in appearance from common russet spot, rib discoloration or spotted wilt virus. The symptoms include rusty-tan spots or confluent areas on inner leaves adjacent to normal appearing ribs near the base of the head. It is especially severe on winter-grown Arizona lettuce that is over mature when shipped from areas having unusually heavy rains. The disease develops in transit and may get progressively severe as lettuce moves to eastern markets. No organisms have been cultured from leaves showing typical symptoms.

Carrots. Thielaviopsis basicola (black mold rot) was isolated from infected Texas carrots. Two hundred sound carrots from random market surveys have failed to yield either of the reported black mold rot fungi, T. basicola or Chalaropsis thielavioides.

Geotrichum candidum was easily isolated from several lots of carrots regardless of condition or growing area, indicating the universal presence of this pathogen in carrot soils. The pathogen was also isolated from diseased tissues of honeydew melon, cantaloup, squash (acorn and calabaza), yuca, ñame, sweetpotato and tomato.

Garlic. Symptoms similar to waxy breakdown developed in garlic when held at about 115° F. and above. When held at 75-78°, waxy breakdown symptoms failed to develop, nor did they develop at 70° F. when held in high CO₂ and low O₂ atmospheres. (HC-18 and 23)

7. Losses in lettuce during marketing. During the 1967-68 marketing year, losses of western lettuce in the New York metropolitan area averaged about 17% through the consumer level. Of this total loss, about 8% represented trimming of unusable material at the ultimate use level. Decay, tipburn, and russet spotting caused most of the 4% loss at wholesale whereas bruising and breakage and russet spotting were major causes of loss at retail and by the consumer. In the Chicago market losses over the same period averaged about 19% with a major part of the loss at ultimate use. (HC-19 and 24)

RPA 501 - IMPROVEMENT OF GRADES AND STANDARDS

1. Bulk Bin Sampling of Processing Tomatoes. Eighty bulk bins (800 lb. capacity) were sampled under commercial conditions with 2 dry-type bulk bin samplers to determine any adverse effects caused by the bulk-bin sampling devices. Analysis of the data showed no overall difference between sampling machines. The mean of the two samplers tested showed that sampling outlets caused damage to the tomatoes in excess of the initial drop onto the conveyor and into the refill bins. Tomatoes in the bottom part of the bin, particularly those that were hand harvested, were damaged more than those in upper locations. Mechanically-harvested tomatoes did not show as much damage as hand-harvested fruit because of pre-sorting on the harvester or possibly varietal difference.

Time studies made with the bin samplers showed that major problems were removal and replacement of bulk bins from specified positions in the grower's load. (HC-61)

2. Maturity Separation of Mature-Green Tomatoes. Single-beam spectrophotometer curves of two wavelength pairs (510 and 580 nm, and 580 and 640 nm) were tested to provide separation of immature from mature-green tomatoes. Narrow band interference filters were used in a 4-filter difference meter to measure the differences in optical density [$\Delta OD(510-580 \text{ nm})$ and $\Delta OD(580-640 \text{ nm})$] to separate tomatoes into maturity categories. The ΔOD values for both wavelength pairs were interpreted simultaneously by the instrument operator since a single wavelength pair did not give satisfactory separation. All sorted tomatoes were held at 60° F. for ripening. Size of fruit and variety affected accuracy of sorting and voids in the center of fruits caused erroneous measurement in the immature fruit, but not in mature-green fruit. Where voids are a problem, removal by specific gravity solutions could be used prior to light transmission sorting. (HC-13)

3. Removal of Undercolor Tomatoes from Inspection Sample. Measurement of delayed light emission (DLE) of whole tomatoes was made but since many acceptable fruits were rejected emphasis was redirected to measurement of the fresh juice. As a direct result a new dual-purpose instrument is being built which will measure both the DLE and relative chlorophyll content of a composite juice sample and provide a measure of undercolor tomatoes in the sample. The same sample could be used for the Tomato Color Index (TCI) and *Drosophila* egg detection. (HC-62)

Publications - USDA and Cooperative Program

RPA 404 - QUALITY MAINTENANCE IN MARKETING FRUITS AND VEGETABLES

Quality Maintenance in Handling and Packaging

- Ceponis, M. J. and Kaufman, J. 1968. Effect of relative humidity on moisture loss and decay of eastern lettuce prepackaged in different films. USDA, ARS 51-18. (MQ 2-80)
- Kushman, L. J. 1967. Preparation of sweetpotatoes for market. USDA, MB 38. (HC-52)
- Kushman, L. J. and Pope, D. T. 1968. Where do we go from here? Presented at the U.S. Sweet Potato Council Meetings, Wrightsville Beach, N.C., February 1968. Published in "Timely Tips," Dept. of Food Science, N.C. State Univ., Raleigh, N.C. (HC-52)
- Lipton, W. J. and Uota, M. 1968. Salvaging of unripe processing tomatoes harvested by machine. USDA, ARS 51-22. (Exploratory)

Quality Maintenance in Storage

- Covington, H. M., Pope, D. T., Kushman, L. J., Nielsen, L. W. and others. 1968. Grow quality sweet potatoes. N. C. Agr. Expt. Sta. Circ. 353. (HC-52)
- Kushman, L. J. and Pope, D. T. 1968. Procedure for determining intercellular space of roots and specific gravity of sweetpotato root tissue. HortScience 3(1):44-45. (HC-52)
- Kushman, L. J. and Wright, F. S. 1968. A new system for curing and storing sweet potatoes. (Abstr.) Association Southern Agricultural Workers 65th Annual Convention Proceedings, p. 166. (HC-52)
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- Lipton, W. J., Harris, C. M. and Couey, H. M. 1967. Culinary quality of cauliflower stored in CO₂-enriched atmospheres. Proc. American Society for Horticultural Science 91:852-859. (HC-31)
- McColloch, L. P. and Vaught, C. 1968. Refrigerated-storage tests with lima beans in the pod. USDA, ARS 51-23. (HC-5)
- Wright, F. S., Splinter, W. E. and Kushman, L. J. 1968. Influence of variety, time from harvest, and storage conditions on mechanical properties of the sweet potato. ASAE Trans. 11(1):81-85. (HC-52)

Quality Maintenance During Transportation

- Stewart, J. K. and Harvey, J. M. 1967. Temperatures, relative humidity and atmosphere composition in a mechanically-refrigerated car and a trailer loaded with lettuce. USDA, ARS 51-13. (HC-32)
- Lipton, W. J. 1968. Low O₂ atmospheres. Benefits and dangers. A report on head lettuce and potatoes. United Fresh Fruit & Vegetable Association Yearbook, pp. 99-100, 103. (HC-32)

Postharvest Disease Control

- Kaufman, J. and Lorbeer, J. W. 1967. Control of Botrytis neck rot of onions by fungicidal dusts and dessicant chemicals. Plant Disease Reporter 51(8): 696-699. (HC-16)
- Kushman, L. J. and Hildebrand, E. M. 1968. Hot-water treatment, a promising control for scurf and black rot of sweetpotatoes. Plant Disease Reporter 52(6):475-477. (HC-52)
- Lipton, W. J., Harvey, J. M. and Couey, H. M. 1967. Conclusions about radiation--USDA team deals with the question "Does gamma irradiation of fresh fruits and vegetables extend their market life?" United Fresh Fruit & Vegetable Association Yearbook, pp. 173-174, 176, 178, 181. (Terminated)
- Spalding, D. H. and Blomquist, M. C. 1967. Macerating action of extracts of Rhizopus-rotted sweetpotatoes as affected by ions. Phytopathology 57:648. (HC-10)
- Wells, J. M. and Stewart, J. K. 1968. Heat pasteurization and chemical fungicides for control of Fusarium rot of California cantaloups. Plant Disease Reporter 52:262-264. (Exploratory)

POTATOES - MARKET QUALITY

Market Quality Research Division, ARS

Handling, Transportation, and Storage

(RPA 404 - QUALITY MAINTENANCE IN MARKETING FRUITS AND VEGETABLES)

USDA and Cooperative Program

Location of Intramural Work	:	Scientist Man Years, FY 1968
Minnesota	:	1.0
Maine	:	0.2
Maryland (Beltsville)	:	1.0
California	:	0.5
Total	:	2.7

Problems and Objectives

The potato leads all other horticultural crops in terms of tonnage produced. Annual production averages about 15.5 million tons with farm value of about 700 million dollars. It is an important and nutritious food crop. It is being harvested, stored, and transported somewhere in this country every month of the year. Much of the crop is stored for periods from 3 to 8 months with losses during handling and storage averaging about 7 percent. Reduction of deterioration during storage plus improved protection during transportation and terminal market handling could save several million dollars annually.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Providing optimum storage environments.
2. Precutting, curing and storing tuber seed pieces.
3. Transporting potatoes in bulk.
4. Measuring quality objectively and sorting automatically.

Progress - USDA and Cooperative Program

A. Objective Measurement of Quality

1. Texture and turgor measurements. Red Pontiac potatoes stored at 32° and 75° F. for a month were easily distinguishable by measuring the relative frequency of vibration. The large differences in f^2_m values (stiffness coefficient derived from vibrational frequency) indicated that the textures were quite different. Half the potatoes were impacted by a 0.6 lb. weight dropped 20 inches onto each tuber to cause mechanical injury. After holding at 75° F. for 3 days, the discolored tissue in the impact area was carefully cut from the tuber (with a minimum of sound tissue) and weighed. Impacts caused assessable damage to 96% of the potatoes stored at 32° (relatively turgid) and to only 36% of the potatoes stored at 75° (relatively flaccid). Sonic and light transmission measurements on whole potatoes, either immediately or 3 days after impactation, did not correlate significantly with damage as measured by weight of the discolored tissue or differentiate between injured and uninjured tubers. (HC-15)

B. Quality Maintenance in Handling and Packaging

1. Causes and effects of tuber bruising. Injured tubers taken from various stages of the harvesting operation in the Red River Valley and pressure bruised tissues from tubers stored at different depths in a bin were studied histologically. Bruises were not detectable visually when controlled drops or impacts to tubers were 10 inches or less. Tuber size and temperature significantly affected the depth and severity of bruising. Intercellular space determinations showed considerable variation between varieties. (HC-26)

C. Quality Maintenance in Storage

1. Storage of precut seed. Rate of suberization and periderm formation of Red River Valley potatoes was not affected by applications of various concentrations of several fatty acids immediately after cutting. Mercurous chloride inhibited suberization and periderm formation. After a 10-day curing period at 58° F. and 4 weeks' storage at 45° F. and high humidity, seed pieces held without forced air circulation were 80 percent infected with fusarium dry rot. At similar temperature and RH but with an air flow of 5 cfm/cwt. no dry rot developed. Seed pieces cut 1 month after harvest and stored 5 months at 40° F. and 85% relative humidity developed dry rot. Varieties varied in susceptibility to dry rot with Red Pontiac developing the most and Kennebec the least. Treatment with maneb provided the best decay control in cut seed. (HC-25)

In experiments conducted in Maine during the 1967-68 season, precut seed was removed from storage in sound dry, decay-free condition after being cured and stored in bulk for approximately eight weeks prior to planting. Experiments with small lots showed better plant stands with less blackleg and seed piece rot in stored, precut seed than in fresh cut tubers. A half carlot of seed stock was successfully precut, cured in bulk, removed from storage with a bulk scoop and shipped by rail to West Virginia for commercial planting. (HC-49)

2. Prestorage and storage treatments for Maine potatoes. Prestorage washing of Katahdins increased lenticel infection in potatoes harvested from dry or moderate moisture soil. When the soil was wet at harvest, differences after storage were not apparent between those pre-washed and those stored as they came from the field. Lenticel infection increased during storage in Kennebecs submitted to prestorage hydraulic stone separation, but Russet Burbanks were not affected. Decay in tubers with about 10% injury from preharvest frost was controlled with air movement of either 1.2 or 3.0 cfm/cwt. of air at 40° F. However, severe pressure bruising developed in the tubers at these air volumes. Washing and re-storing field-frosted tubers after several months of storage improved market appearance. (HC-50)

D. Quality Maintenance During Transportation

1. Mechanical vs. ice-refrigerated rail cars. Potato temperatures in fan-equipped, ice-bunker cars shipped under full-bunker, standard refrigeration and in mechanically refrigerated cars with the thermostat set at 45° F. both averaged about 50° during transit to midwest and east coast markets. Temperatures in mechanically refrigerated cars with a 55° thermostat setting averaged about 60°. The range of temperature between the coldest and warmest positions during transit averaged about 10 degrees in both ice-bunker cars and mechanical cars with either thermostat setting. Average relative humidities were essentially the same in the ice-bunker car and mechanical cars (87% beneath the load and 91% above the load).

There was no appreciable modification of the atmosphere in the ice-bunker cars, but three of the six mechanical cars had carbon dioxide levels of 4.2

to 5.6% at destination. The market quality of White Rose potatoes was good following shipment in either ice-bunker cars or in mechanical cars with thermostat settings at either 45° or 55° F. (HC-33)

E. Postharvest Physiology

1. Storage temperature effects on tuber respiration. Respiration at 60° F. of Katahdin and Irish Cobbler tubers stored up to 6 months at 32° with warming at 60° every third week was consistently lower than that of tubers stored continuously at 32°. The differences were greater with the Katahdin variety than with Irish Cobblers. Katahdin tubers showed blackheart and mahogany browning after 4 months' storage at 32°. Intermittently warmed Katahdin tubers and Irish Cobbler tubers stored constantly at 32° did not show mahogany browning. Differences in respiration of intermittently warmed and continuously refrigerated tubers of both varieties were most pronounced after 6 months' storage. When tubers warmed at 60° were returned to 32°, respiration was lower than that of tubers constantly at 32°. (HC-7)

F. Postharvest Disease Control

1. Losses in potatoes during marketing. About 1.2% of the tubers in samples of Maine Katahdins in the wholesale New York market were unsalable. There was no measurable loss at retail because the tubers had been prepackaged. Trimming losses in consumer samples averaged 3.6%. Bruising, decay, and sprouting were the leading causes of loss.

White Rose potatoes from California showed losses of 1.3% and 1.5% of the pre-packaged wholesale and consumer samples, respectively. Bruising and decay caused nearly all the loss.

In the Chicago market, White Rose potatoes averaged about 9.5% loss from wholesale through consumer level. Most of the loss was due to mechanical injury and greening. Red Pontiac potatoes from the Red River Valley averaged over 10% loss, with about 4% at the consumer level. Fusarium decay was responsible for much of this loss. (HC-19 and 24)

Publications - USDA and Cooperative Program

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Quality Maintenance in Handling and Packaging

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- Lipton, W. J. 1967. Some effects of low-oxygen atmospheres on potato tubers. American Potato Journal 44:292-299. (HC-33)
- Stewart, J. K. and Couey, H. M. 1968. Chip color of Kennebec potatoes as influenced by field and storage temperatures. Proceedings American Society for Horticultural Science, Vol. 92. (HC-33)
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Postharvest Physiology

- Hruschka, H. W., Smith, W. L., Jr., and Baker, J. E. 1968. Chilling injury syndrome in potato tubers. Plant Disease Reporter 51(12):1014-1016. (HC-7)

Postharvest Disease Control

- Wilson, J. B. and Johnston, E. F. 1967. Reducing the incidence of bacterial lenticel infection in fall-washed Maine potatoes. (Abstr.) American Potato Journal 44(9) (HC-50)

CUT FLOWERS AND ORNAMENTALS - MARKET QUALITY

Market Quality Research Division, ARS

Handling, Transportation and Storage

(RPA 906 - CULTURE AND PROTECTION OF ORNAMENTALS AND TURF)

USDA and Cooperative Program

Location of Intramural Work	:	Scientist Man Years, FY 1968
Florida	:	1.0
California	:	0.5
Maryland (Beltsville)	:	1.0
Total	:	2.5

Problems and Objectives

During the past 5 years the farm value of floral products and nursery stock has exceeded 1 billion dollars each year. Sales are increasing each year but movement of cut flowers could expand much more rapidly if methods of handling, packaging, and vase life extension were available for mass distribution at reasonable prices. Basic research is needed to determine the nature of color changes, water uptake, and ethylene response in cut flowers and applied research must develop optimum storage and transit environments including the usefulness of modified atmospheres.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Extending the market and vase life of cut flowers.
2. Maintaining true flower colors after harvest.
3. Satisfactory opening of flowers harvested as buds.
4. Storing nursery stocks for optimum growth response at planting.

Progress - USDA and Cooperative Program

A. Quality Maintenance in Storage

1. Carnations. California and Colorado carnations cut as buds with 3/4 to 1 inch of color showing and shipped to Washington, D.C., had a vase life after opening at least as long as carnations cut as open flowers. The vase life at 70° F. in tap water was 6 to 7 days versus 11 to 17 days in various preservative solutions. When ethylene levels in storage were near 0.3 ppm or higher, opening of the buds and vase life after 3 weeks' storage at 33° F. were poor; with ethylene levels between 0.1 to 0.2 ppm, opening and vase life were good. Cornell solution (5% sucrose, 400 ppm 8-hydroxyquinoline sulfate (8 HQC), and 50 ppm silver acetate) was slightly superior to other preservative vase solutions tested to open and to provide a long vase life, especially following storage. Carnation buds loosely wrapped in polyethylene lost 1% or less in weight during shipment from California, and approximately 0.5% during storage for 1 week at 40° or 3 weeks at 33°. (Cooperative with the T&FRD and the University of California at Davis.)

2. Easter lilies. Lilies grown from bulbs previously held 6 weeks at 50° F. in a nitrogen atmosphere produced more blooms and leaves, were shorter, and bloomed later than lilies from bulbs stored in air. The number of blooms was increased about 63%, the number of leaves about 67%, and the time of bloom was delayed an average of 26 days. Similar but less pronounced differences were present in lilies grown from bulbs stored 12 weeks at 32° in nitrogen and in air. Storage at either temperature in atmospheres of 1% oxygen, with or without 5% carbon dioxide, produced results intermediate to those described above. (Cooperative with CRD.)

3. Flowering shrubs. Preservative solutions appear valuable for lengthening the vase life of cut flowers from ornamentals such as forsythia, lilacs, and dogwood. A solution of 2% sucrose, 400 ppm 8-HQC, and 300 ppm "Alar" gave a vase life of 8 to 10 days at 70° F. for each of these flowers, as against only 4 to 5 days in water. (HC-8)

4. Roses. The life of Better Times roses was doubled when kept in solutions of 8-HQC and sucrose. Sucrose closed the leaf stomates and flowers sustained greater fresh weight than controls. 8-HQC increased water uptake by eliminating physiological plugging of the vascular tissue. (HC-71)

5. Gladiolus. Sucrose and 8-HQC combined at 4% and 600 ppm respectively, increased the vase-life of cut gladiolus. This combination produced greater flower fresh weight, more open and larger florets. The effects of 8-HQC and sucrose on gladiolus were increased water uptake and decreased water loss through transpiration.

Gladiolus held for 3 days (simulated shipment) at 40° or 50° F. in polyethylene or paper wrappers showed no differences in opening or keeping ability due to the type of wrapper. (HC-71)

6. Chrysanthemums. Chrysanthemums cut in the bud stage were successfully opened in 8-HQC and sucrose mixtures, in light intensities as low as 100 foot-candles for 8 hours a day after 32° F. storage for 3 weeks. The flowers were of best quality in winter and inferior in spring. Cultivar responses varied widely. (HC-71)

B. Postharvest Physiology

1. Color retention in cut flowers. Better Times roses placed in sucrose solutions kept longer and did not develop blue color like similar roses held in water. This cultivar contains at least 5 pigments, a single anthocyanin and 4 other flavonoids. These flavonoids are derivatives of the flavonol quercetin.

There are 3 anthocyanins common to the chrysanthemum varieties Delaware, Deep Mermaid, and Velvet Ridge. Principal anthocyanin is Cyanidin-3-glycoside. The other 2 anthocyanins are cyanidin derivatives but their glycosidic structures are not known at present. There is a fourth anthocyanin present in Velvet Ridge but it has not been identified. (HC-70)

2. Carnation responses to ethylene. A high incidence of "sleepiness" in commercial shipments of carnation blooms was related to abnormally high concentrations of ethylene gas (100 to 500 ppb) in the atmospheres of shipping containers, load compartments in trucks, and in ambient atmosphere at shipping points in the San Francisco Bay area. Exposure to 125 ppb ethylene for 20 hours at 70° caused "sleepiness" in some blooms and 250 ppb caused the disorder in 100 percent of the blooms. Blooms held dry prior to the ethylene exposure usually were more susceptible to ethylene damage than those in which the stems had been placed in water.

Carbon dioxide concentrations of 7 to 10% substantially reduced sleepiness in blooms exposed to 250 ppb of ethylene. Twenty percent CO₂ was more effective than lower concentrations and caused no injury to the blooms. Exposure to 30% CO₂ caused abnormal color changes and petal injury. The 20% concentration of CO₂ also controlled sleepiness in an atmosphere containing 1,000 ppb ethylene, but lower CO₂ levels did not.

Carnations placed in a solution containing sucrose, ethanol, and N-dimethyl-aminosuccinamic acid for 24 hours prior to exposure to ethylene had slightly less sleepiness than blooms placed in water. This solution also was effective in increasing the vase life of the flowers at room temperature and blooms held in the solution were larger after 2 or 3 days than those held in water.
(HC-34)

Publications - USDA and Cooperative Program

Quality Maintenance in Storage

Hardenburg, R. E., Uota, M., and Parsons, C. S. 1968. Refrigeration and modified atmospheres for improved keeping quality of cut flowers. 12th International Congress of Refrigeration (Madrid, 1967) Proc. Vol. III.
(HC-8)

Uota, M. and Garazsi, M. 1967. Quality and display life of carnation blooms after storage in controlled atmospheres. USDA, MRR 796. (HC-34)

HORTICULTURAL CROPS - MARKETING FACILITIES, EQUIPMENT AND METHODS

Transportation and Facilities Research Division, ARS

(RPA 503 - PHYSICAL AND ECONOMIC EFFICIENCY IN MARKETING HORTICULTURAL CROPS)

USDA and Cooperative Program

Location of Intramural Work	Scientist Man-Years FY 1968
<u>Citrus fruits</u>	
Florida	0.8
Georgia	.2
<u>Deciduous fruits and tree nuts</u>	
Georgia	1.7
Washington	2.2
<u>Potatoes</u>	
Minnesota	2.2
Maine	1.2
Florida	.1
Maryland	.2
<u>Vegetables</u>	
Florida	1.3
Georgia	.3
Total	10.2

Intramural program is supplemented by extramural support representing 1.2 SMY's at State Agricultural Experiment Stations.

Problems and Objectives

Returns to producers and prices paid by consumers for horticultural crops are adversely affected by the use of inefficient marketing facilities, equipment and methods. Better work methods, techniques, devices, operating procedures, equipment, and facilities are needed for precooling, conditioning, storing, handling, cleaning, washing, waxing, sorting, sizing and packing potatoes, citrus fruits, deciduous fruits, vegetables, nuts, and other horticultural crops. Such improvements at shipping points would increase the productivity of labor, prolong the storage life of the commodities, reduce bruises and injuries to these products, reduce marketing cost, expand consumption, and reflect greater returns to producers.

Major objectives of the research on methods, equipment, and facilities for horticultural crops are to:

1. Reduce labor and costs for handling, storage, and packing.
2. Protect products and provide optimum conditions for commercial storage.
3. Develop improved cooling, conditioning, and storage techniques and procedures.

Progress - USDA and Cooperative Programs

A. Citrus Fruits

1. Handling, Degreening, and Packing. This research, in cooperation with the Florida Agricultural Experiment Station at Gainesville, is directed toward developing improved methods, devices, equipment, and facilities for conditioning, handling, and packing citrus fruit at shipping points. Data on photoelectric color sorting of citrus fruit were analyzed and a manuscript written. In 7 tests on degreening of oranges sorted into 4 color groups, greenest fruit took from 1 to 2 days longer to degreen than yellowest fruit. Amount of fruit degreened at given time different for each of the four groups. Some significant differences were found in internal quality factors between color groups at specific times during season. Significant increase in decay was found with increased degreening time. Initial fruit color and decay were not related. Washing fruit improved uniformity of color sort and did not hinder degreening. Hamlin, Valencia, and Temple oranges and limes sorted successfully into uniform color groups for better market appeal. Photoelectric color sorter could sort out fruit with large surface defects but not small ones.

Initial analysis showed that a fully automatic bagging machine costing \$20,000, using one-third time of an attendant, must replace more than four semiautomatic machines costing total of \$8,000, using one operator each for filling and closing, to save at least \$1,000 per year; ownership cost based on 10-year life for equipment; labor at \$1.60 per man-hour. Data on commercial trial of a 14-head, weigh mechanism, semiautomatic bag-filling machine

showed a production rate of 40 5-pound poly film bags per minute with two workers checking bag weight and automatic bag hanging and closing units attached. Saving of at least \$1,000 per year indicated for this machine versus current count-mechanism, semiautomatic machines, for annual volume of one million 5-pound poly film bags. Weigh machine for poly net bags required 4 workers; count-mechanism machine usable for net bags needed same size crew. Experimental channel-type bag-filling device was modified and tested. Test showed this low-cost device can be used to do both bag-filling and machine-assisted place packing. Contacts made with equipment manufacturers on mechanizing master cartoning of bagged fruit. Laboratory-scale test of 200-watt unit showed ultrasonic cleaning ineffective on oranges and grapefruit.

Manuscript was written on, "Modernizing Handling Systems for Florida Citrus Fruit--Picking to Packing Line;" to supersede MRR No. 529, "Handling Florida Oranges in Pallet Boxes," April 1962. Possible saving with pallet box over field box system is \$45,000 for annual volume of 500,000 field boxes rather than \$23,400 shown in MRR No. 529. For comparable volume, full bulk system offers savings of \$42,000. Same savings potential for modified bulk as for pallet box system not considering presizing and pregrading which can be conveniently incorporated in the modified bulk and also the full bulk system. Cost per pallet box essentially the same using either boom-type lift or tractor forklift for grove operations. Slatted, metal-bound, wood pallet boxes have shown good performance relative to their cost, in Florida. Some trouble with metal bands loosening. Plywood boxes, recently made available in the Florida citrus area, put in use for part of needs of several packing-houses. Insufficient data for comparison of maintenance costs for the two types of boxes. From limited use of straddle trailer in pallet box system in Florida, studies indicate potential savings for this equipment, over flat-bed semitrailers, when distance of one-way haul less than 11 miles. At 5 miles the indicated saving is 2.8 cents per field box equivalent. A device was developed for attaching to pallet boxes to count cycles of use by actuation in the dumping operation. This is a low-cost device for gathering data on the useful life of pallet boxes.

2. Cooling. At Orlando, Fla., and Athens, Ga., research on thermal properties and heat transfer characteristics was continued by further revision of a manuscript for a technical bulletin entitled "Thermal Properties and Heat Transfer Characteristics of Marsh Grapefruit."

At Gainesville, Fla., the report on a study of the performance of an experimental forced-air precooler at the University of Florida Campus Packinghouse with Florida citrus was edited for publication as a marketing research report. The manuscript now has the title "Experimental Forced-Air Precooling of Florida Citrus."

A manuscript was written on, "Forced-Air Precooling Citrus Fruit on a Moving Conveyor." Cooling air temperature can be well below fruit freezing point under controlled conditions without injuring the fruit. Fruit was at 85° F.

for container tests. Temperature data obtained as mass average showed mean temperature reduction in 30 minutes for Valencia, Pineapple and Temple oranges and Duncan grapefruit was 33° F. in open cartons and 38° F. in open crates; closing containers halved cooling rate. Temperature was reduced 40° F. in 30 minutes for fruit in poly net bags. Comparable cooling in poly film bags took 45 minutes. Temperature reduction of Valencia oranges in bulk was 22° and 16° F. for sizes 324 and 126, respectively, in 20 minutes from 80° and required 1 watt-hour per pound per degree F.

B. Deciduous Fruits and Tree Nuts

1. Handling and Packing Apples and Peaches. At Wenatchee, Wash., major changes were made in the prototype brush-roll sorting and sizing line for apples. Commercial runs with the unit indicated that the sorting, polishing, and packing operations were performed at a level equal to or greater than that for existing grading lines. Sizing was satisfactory, except for size 88 and larger. Because of machine design it was not possible to separate the brushes sufficiently to properly size these large apples. Sorters preferred grading fruit on brush-rolls, and after packers gained experience they preferred packing from the return-flow belt. A major problem was the "jamming-up" of fruit of one size in the let-down system associated with the sizer component. At the end of the packing season extensive modifications were made in the unit to eliminate defects. Results of tests on this machine indicate that its low incidence of bruising may at last permit packinghouse operators to pregrade their fruit without suffering the damage that occurs with existing equipment.

The manuscript "An Evaluation of Electronic Color Sorting of Apples" was completed. Only two electronic color sorters have been in operation in apple areas of the Pacific Northwest (only one during 1967-1968 season), and packinghouse operators generally have had little opportunity to observe and study their operation. This report describes the machine and its operation, and discusses its relationship to other packinghouse operations. The major finding was that the electronic color sorter, at its present cost and limited function, cannot be economically justified for the great majority of apple packinghouses.

At East Lansing, Mich., research was continued under a research contract with Michigan State University on the development of a hydrohandling system for prestorage sorting and sizing of apples. Under an amendment to the contract specified modifications were made in the prototype system, installed at a commercial apple packing and storage house at Belding, Mich., and tests of the modified system were conducted. During the 1967 harvest, runs were made with the prototype system using orchard-run apples which were received in pallet boxes of approximately 20-bushel capacity, emptied, sorted, sized, and filled back into pallet boxes--McIntosh, Jonathan, and Delicious varieties were included. Tests involved evaluation of mechanical damage, factors affecting the decay of apples stored in controlled atmosphere, and sizing efficiency. Preliminary results of these tests indicate that the

hydrohandling system will be satisfactory for Jonathan, Delicious and other "hard" varieties, but not for the tender McIntosh variety. Mechanical damage, evaluated after a storage period, indicated that additional developmental work will be necessary to provide sufficiently gentle handling before pre-storage sorting and sizing will be acceptable for the McIntosh variety.

At Athens, Ga., in cooperation with the State Agricultural Experiment Station, the study to evaluate existing methods of performing peach packinghouse operations was continued. A comprehensive analysis and evaluation of existing methods of making up packing materials and supplying them to the packing line was completed. Additional data on labor and equipment requirements for the grading and filling operations were obtained to supplement that obtained in previous years. Previous work under this project showed that pallet box handling of peaches is economically feasible, but it pointed out the need for improved pallet box dumping equipment that could be economically adapted to a low-volume (200 - 400 bushels per hour) operation. A study to design, develop, and test an improved pallet box dumper was initiated. A dumper was designed and a quarter-scale prototype constructed and tested. Results of preliminary tests justify construction of a full-scale model for installation and testing in a commercial packinghouse. Acquisition of materials and supplies for construction was initiated. A manuscript entitled "Handling Peaches in Pallet Boxes" was prepared for publication.

2. Storage of Apples. This area of work at Wenatchee, Wash., involves: (1) Investigations of airflow distribution methods, patterns, and rates in refrigerated fruit storages to determine and evaluate the influence of these factors on cooling fruit and bringing it to optimum storage temperatures; (2) determining and evaluating heat gain through various structural features of fruit storages as a basis for improving designs; (3) redesigning storage houses for the most efficient handling and storage of fruit in pallet boxes; (4) evaluating the hydrocooling of apples before they are placed in storage; and (5) developing improved methods, techniques, equipment, and facilities for controlled atmosphere (C.A.) storage of apples.

Writing was initiated on the manuscript, "Guide for the Cold Storage of Apples and Other Fruit," which will supersede and update Circular No. 740, "Cold Storages for Apples and Pears."

Studies showed that hydrocooling apples at harvesttime has no advantage over room cooling so long as cooling is accomplished in 7 days or less. However, where room refrigeration equipment is overloaded, hydrocooling greatly assists in removal of field heat and reduces total cooling load. Research was completed and a manuscript prepared on "Effects of Hydrocooling on the Dessert Quality and Storage Life of Apples in the Pacific Northwest."

Further observations of commercial controlled atmosphere storage rooms indicates that for airtight C.A. rooms lime scrubbing of CO₂ from the air is becoming more popular. Some storages use the Tectrol system for original pull down, then convert to lime or caustic soda scrubbing.

3. Cooling Deciduous Fruits. At Wenatchee, Wash., writing and preliminary editing of the manuscript on "The Effect of Vent Holes on the Cooling Rate of Fiberboard Boxes" was completed. Findings indicate that the cooling time of packed fruit in fiberboard boxes can be reduced over 50 percent by the addition of enlarged vent holes in the neutral stress areas of the ends of the boxes. These holes do not weaken the box to any great extent. Other studies indicate that regular fiberboard boxes will permit picked fruit to cool satisfactorily when there is adequate air circulation and sufficient refrigeration to remove the heat from the apples rapidly. Air temperatures in the room should be held at 30° to 32° F. for most varieties of apples, the air circulation should be not less than 1,500 c.f.m. per ton of refrigeration, and relative humidity in the room maintained between 85 and 90 percent.

At Athens, Ga., research carried out by the Georgia Agricultural Experiment Stations under a cooperative agreement utilized the Division's prototype forced-air precooler to: (1) Evaluate its performance; (2) investigate cooling effectiveness of apples, strawberries and peaches in relation to system performance; and (3) develop mathematical expressions of heat transfer with respect to product properties and configurations.

Average surface heat transfer coefficients of potatoes and plastic spheres in bulk lots were experimentally evaluated during cooling in the prototype forced-air precooler. From these data, correlations of Nusselt Numbers to Reynolds Numbers at the top, center, and bottom of a 14-inch deep bed of potatoes were computed for use in future design work on commercial forced-air precooling systems. Specially constructed bulk boxes with a capacity of approximately 400 lbs. of peaches or potatoes were filled to one-fourth, one-half, and full load capacity and cooled for periods of one-half hour and one hour, each at approach air velocities of 225 and 375 feet per minute. Cooling rate was evaluated by means of the slope of the time-temperature response curve, converted to logarithms for linearity. Cooling rate was influenced by produce load and air velocity, but to a lesser extent for the one hour period than for the one-half hour period. Cooling rate was generally higher at the half hour period with the higher air velocity, achieving maximum efficiency with the box fully loaded at this condition. Based on refrigerating capacity available, efficiency was 70 percent. Average cooling rate for a typical period of one hour was 0.66 degree F. per minute at the high air velocity.

A manuscript, "Heat Transfer Properties and Characteristics That Affect the Design of Precooling Systems for Apples," has been drafted.

4. Handling, Conditioning, and Shelling Pecans. Research at Athens, Ga., in cooperation with the State Agricultural Experiment Stations, on the conditioning, cracking, and shelling of pecans was continued. Stuart pecans were conditioned by soaking them in water at selected temperatures and steaming them at selected pressures. Changes in moisture content of the pecan kernels and the percent of whole halves obtained in cracking and shelling with commercial equipment were determined for each treatment.

Conditioning pecans before cracking and shelling by soaking, or steaming, resulted in approximately 35 percent more whole halves than was obtained for similar unconditioned nuts. There was no significant difference in the yield of halves between the two treatments but steam offers distinct advantages for potential commercial application. Pecans steamed for 5 minutes yielded approximately the same percentage of halves as pecans soaked for 2 hours then held for 12 hours before cracking. In addition to being faster, the steam treatment did not increase the moisture content of the kernels as much as the soaking treatment. The advantage of obtaining a higher yield of halves at a lower moisture content is that less moisture would have to be removed by drying prior to shipment. Moisture content of the shell, as well as of the kernel, will be evaluated in future studies of this type.

C. Potatoes

1. Handling and Packing Potatoes. Research at Presque Isle, Me., in cooperation with the Maine Agricultural Experiment Station, involves the development of more efficient work methods, operating procedures, equipment, and facilities for handling, storing, and preparing potatoes for market.

Joint work was continued on preparation of the manuscript, "Supplying the Packing Line with Potatoes in Maine Storages at Rates of 200 Hundredweights Per Hour and Above."

Under a research cooperative agreement, the Maine Station continued work on the design and construction of an improved sizer for "long" white potatoes. A number of modifications were made in the prototype potato sizer after it was moved from Orono to Presque Isle, including the installation of modified expanding rubber rolls on two lanes. The other two lanes still have wood rolls. Further modification and tests will be necessary to provide the basis for a design suitable for commercial use.

Under a second research agreement, the Maine Station continued research on designing and testing hydraulic handling systems for potatoes and other crops. Difficulties were encountered during tests with the closed system using a jet injector and, as a result, modifications were made which permitted tests to be performed at steady state conditions. Data were gathered on flow characteristics of potatoes in a 200-foot long, 8-inch bottom width trapezoidal flume. The test flumes were modified to provide a 10-inch bottom width. Rectangular metal sections to form 200 feet of flume were fabricated. Trials were conducted with this open channel rectangular cross section flume. Runs were completed and data assembled, but not analyzed.

Research at Gainesville, Fla., in cooperation with the State Agricultural Experiment Station, involves development of more efficient work methods, operating procedures, and equipment for the handling and preparation for market of potatoes in spring-crop areas. In a Hastings area packinghouse a new semiautomatic machine for filling 50- and 100-pound bags, which used a sewing machine to close the burlap bags, was time studied and bag weight

data were obtained. Analysis of cost reduction potential for new filling machine was incomplete, but indicates three workers produce 8 to 9 filled and closed 100-pound bags per minute in continuous operation. Additional data on weighing accuracy and delay caused by sewing machine are needed. Earlier data on manual filling and weighing and hand sewing indicate 1.5 to 2 times as much labor required as for the machine filling and sewing method. However, this efficiency would be offset in part by costs of semiautomatic filling and weighing machine at \$11,000; sewing machine at \$2,500. Possible application of commercially made photoelectric equipment for sorting potatoes for surface defects followed up. Consultation with equipment manufacturer shows equipment with required capability not yet available.

At East Grand Forks, in cooperation with the Minnesota and North Dakota Stations, work involves developing more efficient work methods, techniques, devices, and equipment for the handling and preparation for market of mid-western fall-crop potatoes. Work was completed on manuscript, "Handling Potatoes from the Storage to the Packing Line," covering 42,000, 60,000 and 120,000 cwt. storages using fluming, forking to conveyors, and bulk scooping systems at per hour rates of 100, 200, and 300 cwt. and the maximum rates for individual systems. Powered bulk scoop operations were analyzed relative to storage size, bin size and arrangement, hopper location, travel distance, and scoop performance. Optimum bin size-bin arrangement-hopper location-storage size combinations have been worked out for several 30,000 to 400,000 cwt. storages. A new proposed technique using fully movable hoppers increases powered bulk scooping capacity for trips greater than 50 feet and possibly will double output at distances greater than 150 feet. Several commercial packinghouse layouts were analyzed for process flow, operations and efficiency. Preliminary plans were developed for future packinghouse, packing and storage systems and layouts. Research was continued on the impact of cleaning and sizing fall-crop potatoes before storage. Sampling data of potatoes taken from a 120 cwt. bulk truckload indicated a normal tuber size distribution if allowance was made for tubers under 1.5 inches in diameter eliminated by the harvester. A 113 tuber (50-pound) sample resulted in a standard error of the mean of about .05 inch. Completed compilation of data on ring and tube hand sizing accuracies. Found no statistically significant method differences. Actual observations by different workers were significant. Outline for manuscript concerning the feasibility of sizing into storage partially developed.

2. Storage. Storage research at the Red River Valley Potato Research Center, East Grand Forks, involves providing optimum storage conditions for fall-crop potatoes for table stock, seed, and processing; and developing improved layouts and designs for potato storage houses.

Research to develop improved designs for above-ground potato storage for the fall-crop area was completed. Plans and specifications for a 60,000 cwt. cross alley potato storage were published. Completed design, drafting and specifications for 25,000 cwt. pallet box potato storage, the final set of four plans and specifications to be developed for storages for potatoes.

Drafted manuscript, "Bin Fronts for Potato Storages," pertaining to 20-foot spans. Revised and updated manuscript "Fall Crop Storage and Handling of White Potatoes."

Research on providing optimum conditions for the storage of potatoes for processing was continued. Selected temperature centroid, isotherms, temperature differences, temperature difference ratios, and mean and standard deviation as methods for representing and analyzing storage temperatures. Completed system design and instrumentation on two stage, direct expansion refrigeration system to be tested at low temperature and high humidity conditions.

At Presque Isle, Me., studies were conducted on airflow patterns in mechanically ventilated bulk potato piles. The duct configurations investigated were rectangular and triangular shaped center ducts and triangular shaped side ducts. The rates of supply air were 0.75, 1.0, and 1.25 c.f.m./cwt. The low air velocities in the potato pile were sensed with a specially designed airflow meter, constructed with paired thermistors in its circuit. The triangular shaped ducts produce no distinct difference in airflow patterns from rectangular ducts as the air passed through or emerged from the top of the potato pile. Since airflow rates are considered to influence weight loss and pressure bruising, a statistical analysis of weight loss versus pressure bruise index was initiated. Incidence of weight loss, pressure bruising, and internal black spot of tubers as affected by levels of relative humidity at a constant 45° F. temperature were studied. Two potato varieties, Russet Burbank and Norland, were selected for the study. The potatoes were subject to pressure levels of 150, 350, and 500 pounds ft.². The levels of relative humidity were controlled at 99, 88, and 79 percent. The tubers were removed from storage after 6 months and evaluated for injury based on U.S. No. 1 and 2 grades. Analysis of the data was not complete at the end of the report year.

D. Vegetables

1. Handling and Packing. In cooperation with the Florida Agricultural Experiment Station at Gainesville, research on handling and packing vegetables involves the development of improved work methods, devices, and operational procedures for the handling and preparation for market of vegetables at Florida shipping points.

Manuscripts were completed on mechanically sizing and centrally packing celery. Accuracy of the electronic scale was +0.058 pounds compared with +0.088 pounds for the mechanical beam type and +0.394 pounds for the hand sizing method. The central packing system required 40 percent fewer workers than the field packing method and reduced labor and equipment costs by 18.4 cents per crate. Data obtained on carrot packing show labor requirements were 0.142 man-minutes for one pound and 0.208 man-minutes for two-pound packages. Data analysis of overweight packages indicates a daily product loss of almost 18,000 one-pound packages in an average packinghouse.

Preliminary data on vine-ripened tomato weights and diameters indicate a range of 19 to 22 pounds for a 20-pound carton with random selection of a predetermined number of fruit within a size category. Data on photoelectric color sorting of tomatoes were analyzed and a manuscript was drafted. The optimum wavelength combination for measuring color at varying levels of maturity by light reflectance was 540-590 nanometers. Machine sorting was satisfactory except in sorting green fruit from those with a slight color break. Data showed a significant difference in color between four groups after sorting. Differences were smaller as fruit ripened, with little difference after 6 or 7 days. In work on development of improved photoelectric sorting equipment, spectral reflectance curves for various products were obtained and information on photocells and fiber optic units was compiled.

Research conducted by the Florida Station under a cooperative agreement to develop design principles for a mechanical celery stripper was limited to exploration of possible approaches and providing a basis for future work. Celery was obtained directly from the field with the outer petioles still intact and the stalks were dropped from heights of 5 feet and 6 feet through a 12-inch tube onto a metal plate. With a 5-foot drop, petiole removal was not effective. A 6-foot drop did not give effective petiole removal and stalk damage became noticeable. Only a few petioles were removed in total and, in most cases, none were removed from a stalk of celery. From the drop tests, it was concluded that another approach would be required to obtain satisfactory removal of the unmarketable outer petioles. In another test celery stalks were tumbled in a barrel-shaped chamber. This showed no results which would justify further research effort in this direction. One small-scale test, with a hand-held knife, did show promise for effective petiole removal, however. This involved progressively cutting off the butt end of the stalk to a depth sufficient to free the unwanted petioles. Further work will be done to construct an experimental unit to test this concept for development of an automatic machine.

Recent developments in the production and harvesting of tomatoes, such as mechanical harvesting for processing, has brought about an urgent need for the development of larger containers than field boxes for handling this commodity. Research on handling and ripening tomatoes in pallet boxes was undertaken and completed at East Lansing under a cooperative agreement with the Michigan Agricultural Experiment Station. Results of this research were published in Marketing Research Report No. 802, "Handling Tomatoes in Pallet Boxes."

Research designed to increase the efficiency and reduce the unit cost of handling, curing, storing, and preparation for market of sweetpotatoes and to minimize losses from spoilage and deterioration was conducted at Raleigh under a cooperative agreement with the North Carolina Agricultural Experiment Station and the North Carolina State Department of Agriculture. During the report period effort was confined to editing the manuscript, "Optimum Lowest Cost Sweetpotato Harvesting and Handling Systems."

2. Cooling. This research is designed to develop improved methods, operating practices, and techniques for use in existing and new facilities for more efficient cooling of vegetables.

At Athens, Ga., laboratory apparatus was put into operation and calibrated to relate fan speed with volume rate of airflow. Shapes of acrylic plastic were prepared for use in evaluating heat transfer coefficients. Tests to determine the effect of air temperature and flow rate of appearance and time-temperature response of sweet corn were carried out. Treatments included air at 0° F., 10° F., and 20° F. at velocities of 400, 830, and 1220 feet per minute. One ear of corn with the husk on and one ear with the husk removed and wrapped in thin polyethylene were subjected to the same treatment. The mass-average temperature of corn in air at 0° F. and 400 feet per minute reduced from 70° F. to 40° F. in 20 minutes and to 35° F. in 30 minutes. Removing the husk did not significantly increase cooling rate. Dessication was apparent around the edges and on the tips of the husk. Trimming and removal of outer layers restored fresh appearance. Browning, indicating frost or freeze injury, was found around the base of the ear.

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CONSUMER PACKAGES AND SHIPPING CONTAINERS

Transportation and Facilities Research Division, ARS

USDA and Cooperative Program

Location of Intramural Work	Scientist Man Years F.Y. 1968			
	Research Problem Area			Total
	503	601	906	
<u>Fruits and Vegetables</u>	:	:	:	:
Maryland (Hyattsville)	: 2.7	: 1.0	:	: 3.7
California	: 1.0	: 0.1	:	: 1.1
Florida	: 0.9	: 0.1	:	: 1.0
Washington	: 1.2	: 0.8	:	: 2.0
Total F & V	: 5.8	: 2.0	:	: 7.8
<u>Floral Products</u>	:	:	:	:
California	:	:	: 0.9	: 0.9
Total	: 5.8	: 2.0	: 0.9	: 8.7

Intramural program is supplemented by extramural support representing (a) .3 SMY's at State Agricultural Experiment Stations, and (b) .9 SMY's at other U.S. institutions.

Problems and Objectives

Shipping containers and other packaging are indispensable for efficient movement of farm products from widely dispersed areas of production through our complex marketing system to industrial concerns engaged in further manufacturing and to ultimate consumers located throughout the world. It costs about \$10 billion a year to package food products. The American marketing system is characterized by dynamic innovation processes constantly striving to increase efficiency and utility. New and improved packaging is necessary to facilitate desirable changes in transport and handling equipment and techniques, consumer preferences and market organization. New packaging concepts also stimulate improvement in other parts of the marketing system.

This is a continuing program of applied research conducted by marketing specialists, industrial engineers, and agricultural economists. Current research is on deciduous fruits, citrus fruits, vegetables, cut flowers, and poultry products. The program is carried on in cooperation with experiment stations and industry in main producing areas and in the principal domestic and overseas terminal markets. Major objectives of this research are to:

- (1) Develop modular size containers and performance criteria.
- (2) Reduce costs of marketing.
- (3) Protect consumer health by sanitary packaging.
- (4) Provide more services and conveniences to consumers.
- (5) Reduce spoilage and nutritional losses.
- (6) Help maintain and strengthen the competitive position of U. S. exports.
- (7) Help develop new foreign markets.
- (8) Increase the income of producers.

Progress-USDA and Cooperative Programs

RPA 503--PHYSICAL AND ECONOMIC EFFICIENCY IN MARKETING FRUITS AND VEGETABLES

1. Apples. Laboratory tests and three rail test shipments of molded-pulp deep-cup trays trimmed to fit the same box used for conventional molded-pulp shallow-cup trays indicate that containers with trimmed deep-cup trays protected Golden Delicious apples about as well as containers with untrimmed deep-pocket trays but packaging material costs were reduced by 2 cents per box. The pack using trimmed deep-pocket trays cost 11 cents per box less

than corrugated cell-pack containers. The 1968 test data are being incorporated in a report on research done in previous years evaluating cell-pack and tray-pack containers for Golden Delicious apples.

2. Apricots. Jumble-packing apricots in fiberboard boxes and shipping them costs 1.5-cents less per pound than for marketing them place-packed in wood boxes. Damage from bruising was 33 percent in jumble-packed boxes and 36 percent in place-packed boxes. The potential annual savings in packaging and transport costs for all fresh apricots shipped from California, Washington, and Utah in jumble-packed fiberboard boxes would be about \$530,000 per year. A manuscript, "Jumble Packing Fresh Northwest Apricots and Prunes: Comparative Cost and Performance of Wood Boxes, Wood-Veneer Baskets and Fiberboard Boxes," has been prepared.

3. Italian Prunes. Jumble-packing Italian prunes in fiberboard boxes and shipping them costs 1.8 cents less per pound than marketing them face-packed in wood-veneer baskets. Damage from bruising was only 7 percent in the new boxes as compared to 21 percent when prunes were shipped in the wood-veneer baskets. The potential annual savings in packaging transport costs for fresh prunes shipped from Idaho, Washington, and Oregon in jumble-packed fiberboard boxes would be about \$953,000 per year. A manuscript, "Jumble Packing Fresh Northwest Apricots and Prunes: Comparative Cost and Performance of Wood Boxes, Wood-Veneer Baskets and Fiberboard Boxes," has been prepared.

4. Table Grapes. California grapes packed in expanded polystyrene foam shipping containers arrived in Eastern markets with fewer bruised and shattered berries than grapes packed in standard wood display lugs. These results were obtained from test shipments made during the 1966 and 1967 grape seasons. Net savings obtained from packing and shipping grapes in polystyrene boxes were estimated to be 4 to 6.2 cents per box of 26.5 pounds of grapes. Receivers generally liked the polystyrene foam boxes for grapes, although breakage of the boxes was a problem in test shipments. Preliminary tests in which the foam boxes were palletized for shipment as a means of preventing excessive box breakage were partially successful.

5. Temple Oranges. Investigations on Temple oranges packed in plastic cell trays, and place-packed in fiberboard boxes and wirebound crates, have been completed. Sixteen truck test shipments were made from Florida to five Eastern terminal markets. Temple oranges packed and shipped in polyvinyl chloride (PVC) cell trays arrived in terminal markets with less bruising than comparable oranges place-packed in wirebound wood crates or fiberboard boxes. The cost of packing, handling, and shipping (1,000 miles) Temple oranges in the PVC cell trays and fiberboard boxes was \$1.91 per 4/5 bushel box equivalent, \$.94 for wirebound crates and \$.85 for fiberboard boxes.

6. Citrus. Minimum performance standards and container criteria for rating and evaluating Florida orange and grapefruit boxes are being developed in cooperation with the Florida Citrus Commission. The performance standards and container criteria will be used by the Commission to improve the

performance of citrus boxes and to evaluate proposals for new containers. New containers that meet or exceed the performance standards will be considered for further testing and evaluation under commercial conditions.

7. Grapefruit and Murcott Oranges. Exploratory studies of the marketing of ready-to-serve grapefruit halves and peeled whole Murcott oranges were continued. Potential market outlets were explored and chainstore and institutional buyers encouraged continuation of the work.

8. Plums, Nectarines and Bartlett Pears. Investigations to determine the costs and feasibility of marketing Western plums, nectarines, and Bartlett pears packed in three sizes of shipping containers and prepackaging them in terminal prepackaging plants and retail stores were completed by the contractor, Food Industries Research and Engineering. The fruit was packed in place-packed boxes, jumble-packed boxes and large bulk-bin boxes and shipped to Cleveland, Ohio, or Boston, Massachusetts, where it was prepackaged and sold. The final report submitted by the contractor summarizes the work done, presents detailed cost analyses of packaging, handling, transport, and re-tailing these fruits and draws conclusions from the data obtained. Terminal market prepackaging firms and retail stores can reduce their costs of prepackaging plums and pears by buying them in jumble-pack boxes or large bulk-bin boxes. Because of higher spoilage loss in the jumble-packed boxes terminal market prepackaging plants and retail stores can reduce the costs of prepackaging nectarines by buying them in large bulk-bin boxes.

9. Tomato Transplants. In cooperation with Crops Research Division, ARS, the feasibility of developing improved containers for shipping tomato transplants from Georgia to northern tomato producing areas was investigated. Tomato transplants are usually harvested and then graded and packed in bunches wrapped with peat moss and Kraft paper in packing sheds. Less labor and materials are used for packing bunches of tomato plants with bare roots rather than wrapping them with peat moss and Kraft paper. Four truck test shipments of tomato transplants, bare roots and roots wrapped with paper packed in conventional wirebound crates and experimental fiberboard boxes, with and without polyethylene liners, were made from Georgia to New Jersey. Bare root plants packed without box liners were acceptable upon arrival at destination. Leaves of bare root plants in fiberboard boxes with polyethylene liners turned yellow. Plant survival tests at Beltsville resulted in no statistically significant difference in field survival between treatments planted without delay. When plants were stored four or ten days prior to shipment, field survival of bare root plants in wirebound crates and fiberboard boxes without box liners was higher than plants with paper wrapped roots in wirebound crates and bare root plants in fiberboard boxes with polyethylene liners.

10. Standardization of containers for fresh fruits and vegetables. A pilot study on the extent of use, dimensions, net weights and specifications of shipping containers used for fresh fruits and vegetables in the United States was completed under contract by the Research Triangle Institute, Raleigh,

North Carolina. The pilot survey was undertaken in four warehouses, in each of the cities of Los Angeles and New York over four seasons of the year. In the pilot study 44 different size boxes were found in use for apples, 8 for oranges, and 22 for cauliflower.

RPA 601--EXPANSION OF FOREIGN MARKETS FOR U. S.
FARM PRODUCTS

1. Fruits and Vegetables. Investigations to reduce the costs of marketing exported apples were continued. Thirteen test shipments of Golden Delicious, Red Delicious and Newton apples packed in experimental containers and shipped from the Northwest and Virginia to Europe have been completed. Preliminary data indicate that packing and handling apples in 800-pound, 4-cell pallet boxes instead of 42-pound boxes and handling 42-pound boxes palletized instead of individually offer significant savings. Trimming the edges of the molded-pulp deep-pocket tray did not reduce protection to the apples but did reduce container costs by 2 cents per 42-pound box. Packing Golden Delicious apples in trimmed deep-pocket tray pack instead of the conventional cell-boxes used for export reduces the costs of packaging materials by about 26 cents per hundred pounds.

Rutgers University completed a contract studying the feasibility of packing and shipping cell-pack Golden Delicious and McIntosh apples in 50 by 30 cm. boxes--one of the proposed European standard containers. The final report submitted by the contractor presents detailed cost analysis of packaging materials, handling and packing labor costs, transport charges, condition of container and apples when the apples are packed in 50 by 30 cm. boxes and in control boxes (boxes currently used by U. S. apple shippers). McIntosh apples and Golden Delicious apples packed in cell boxes with 50 by 30 cm. outside dimensions did not show any more bruising than comparable apples packed in conventionally used cell-pack boxes in test shipments made from apple producing areas to New York City. The tests indicate that the packing of all the sizes of apples of these two varieties that are exported in one dimensional size cell-box would increase the costs of placing apples in Europe about $\frac{1}{4}$ to $\frac{1}{2}$ cent per pound. A report for publication is being prepared.

Research to develop packaging that will provide better protection for celery shipped to overseas markets was continued. Container specifications and packing patterns were developed for prototype celery shipping containers manufactured from (1) expanded polystyrene foam, (2) wax-dipped fiberboard, and (3) curtain-coated (polyethylene wax) fiberboard boxes. Exploratory van container shipments from Florida to Germany showed that after 16-day average transit periods celery packed in polystyrene containers arrived in excellent condition, green and very crisp. Celery packed in wax-dipped fiberboard boxes arrived in comparable condition to celery packed in

conventional wirebound crates. Two test shipments of celery packed in 2/3 size curtain-coated fiberboard and fiberboard-wood-frame boxes arrived in Puerto Rico and Landover, Maryland, with fewer bruised and broken ribs than celery packed in the conventional wirebound crate.

Development of more efficient containers for soft fruits and citrus for air and boat shipment to overseas markets were continued. Exploratory tests have shown that the use of expanded polystyrene foam boxes can reduce air transport charges. Prototype containers of expanded polystyrene foam and wood have been designed and obtained. The outside dimensions of these containers are 50 by 30 cm. which fully use the space on a 48- by 40-inch pallet or the European 120- by 100-cm. pallet. A fiberboard full-telescope container of this size is also being made. Laboratory analysis of the 50- by 30-cm. container indicates this container will hold about 20 pounds of peaches, plums, or nectarines. Additional research is being conducted to determine the container size and type of material best suited to specific fresh fruits and vegetables. Work to develop a citrus container that would efficiently fit a 48- by 40-inch pallet and would provide adequate ventilation to the fruit in ventilated van container shipments was begun at Orlando, Florida.

RPA 906--CULTURE AND PROTECTION OF ORNAMENTALS AND TURF

Colorado Carnations. The use of different types of box liners and accessory packaging materials for packing Colorado carnations in fiberboard boxes was tested. Polyethylene film laminated to crepe paper and an expanded polystyrene foam liner provided better insulation at less cost than currently used materials such as macerated paper blankets and air cell liner materials. The feasibility of increasing the density of flowers packed in fiberboard boxes and shipped by air is being tested. Packing and shipping 400 cut carnations instead of 200 cut carnations in a standard shipping container can save the Colorado flower industry \$110,000 per year.

Publications--USDA and Cooperative Program

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TRANSPORT EQUIPMENT AND TECHNIQUES

Transportation and Facilities Research Division, ARS

USDA and Cooperative Program

Location of Intramural Work	Scientist Man Years F.Y. 1968			
	Research Problem Area			Total
	503	601	906	
<u>Equipment</u>				
Maryland (Hyattsville)			1.1	1.1
Total Equipment			1.1	1.1
<u>Techniques</u>				
Maryland (Hyattsville)	1.8	2.8		4.6
Florida	0.8	1.1		1.9
Total Techniques	2.6	3.9		6.5
Total	2.6	3.9	1.1	7.6

Intramural program is supplemental by extramural support representing (a) 0.0 SMY's at State Agricultural Experiment Station, (b) 0.0 SMY's at other U.S. institutions, (c) P.L. 480 funds in 6 countries representing \$1,247.90 U.S. dollars equivalent 1/, and (d) 0.8 SMY's at industry firms through contracts 2/.

1/ RPA 601

3/ RPA 503 0.8

Problem and Objectives

The cost of transporting U.S. farm products to domestic and overseas markets in 1967 was about 9.5 billion dollars. In addition, substantial product loss and damage occurred during transport because of inadequate temperature protection, poor loading and stowage methods, and excessive handling of the products. Economic-engineering research to develop and apply new transport and engineering technology to transporting agricultural products can lead to savings of about 1.4 billion dollars annually in marketing costs. This program will help increase returns to farmers, provide better products at lower costs to American consumers, and improve the competitive position of our products in foreign markets.

Major present objectives of the research are to lower costs and improve transport performance by:

1. Developing new refrigeration methods for vehicles used to transport perishable agricultural products.
2. Developing loading and stowage methods to increase cargo space utilization in transport vehicles and reduce damage to packaged products.
3. Reducing the number of handlings of products by means of van containers, palletization, and other unit load techniques.
4. Finding better ways to integrate the various modes of transport to obtain lower total transport and distribution costs.

Progress - USDA and Cooperative Program

Transport Techniques

RPA 503 - PHYSICAL AND ECONOMIC EFFICIENCY IN MARKETING FRUITS AND VEGETABLES

A. Unitized and Palletized Loading and Transport

1. Citrus Fruit. More efficient, lower cost methods of handling and shipping citrus are needed to help offset rising costs in the citrus industry. The purpose of this research is to develop unitized and palletized loading techniques for fresh citrus that will reduce product damage and handling and shipping costs.

Stacking patterns for pallet-size handling units of citrus were developed for the 4/5-bushel box and the bagmaster box. The handling units were tested for stability and for adequacy of air circulation when loaded in a trailer. A fully loaded trailer contains 18 handling units. The pallet size used was 48 by 40 inches because this is the size most generally used by food distribution industry. It was found that handling units of the 4/5-bushel boxes and bagmaster boxes on pallets did not provide a large enough payload. A handling unit of 54 boxes of the 4/5-bushel size was developed for slipsheets that would provide a large enough payload.

Tests were made in an air circulation chamber to compare the cooling rates of boxed citrus using different types of containers, stacking arrangements and types of pallets. The cooling rates of the handling units arranged in the tight-stacked and air-flow patterns were compared. The results indicated that during the critical initial cool down period the air-stack pattern had a greater rate of cooling than conventional tight stack pattern during the first 18 hours. After 18 hours, the cooling rates were almost identical for the two patterns. Also, tests were made to compare cooling rates in the conventional 4/5-bushel box, air-flow pattern with air introduced into the load at the top front of the test chamber; and a 4/5-bushel box with grid pattern openings cut into the tops and bottoms and in a tight-stack pattern with air introduced into the load at the floor level. Test results indicated that the experimental box permitted air circulation throughout the load. But the grid pattern cut into the experimental boxes weakened them. The bottoms broke out of 4 percent of the boxes when handled after 48 hours under refrigeration.

Twelve highway trailers and one rail piggyback shipping tests were made with air-flow and tight-stacked handling units on disposable pallets and slipsheets. Some load shifting was observed at destination in three of the loads with the air-flow handling units, resulting in some blockage of air channels. Product temperatures in loads arriving in this condition were from 5° to 8° F. higher in the center than around the periphery of the load. But the air-flow loads generally arrived in good condition with less temperature variation throughout the load than in the tight-stacked loads. Tight stacked shipments arrived in good condition with little or no load shifting. The disposable pallets proved unsatisfactory. The weight of the handling units combined with the motion of the trailer over the road caused some disposable pallets to collapse. Others had stringers which were not of sufficient height to permit entry of the forks on the electric transporters used for unloading. All the disposable pallets tested cost over \$1.00 each and were not considered economically feasible.

Labor and equipment data were obtained to compare costs of unitized shipments with those of the conventional hand stacking methods. Labor input data obtained for unitized shipments are not considered representative for unitized handling. Inexperienced personnel operating equipment for handling slipsheets required more time than was considered necessary for loading and unloading operations. Inexperienced in loading results in some of the tabs on the slipsheets becoming crimped so that they could not be gripped by the special attachment on the forklift without manual assistance.

The 4/5-bushel box is the predominant container used for shipping citrus. Both the corrugated and wirebound 4/5 bushel boxes are well suited for the stacking arrangements used to make up the handling units. A survey was conducted at 29 of the 35 larger citrus packinghouses in Central Florida to determine the type of plant facilities and equipment in current use. The results showed that the larger packinghouses had loaded platforms and space for stacking, handling and storing that would permit them use of a unitized loading system. The main deficiency was in the type of equipment used. Only half the houses surveyed had forklift trucks which could be adapted with attachments for handling pallets and only two had forktrucks equipped to handle slipsheets. But the type of equipment needed is available from the various equipment manufacturers.

2. Potatoes. A report covering the results of exploratory research to determine the feasibility of developing more efficient, lower cost methods of unitizing consumer size bags of potatoes was received from the contractor, Food Industries Research and Engineering, Inc., Yakima, Washington. The study sought to determine, from both the engineering and cost standpoints, the feasibility of unitizing, automatically and semi-automatically, 10-pound bags of potatoes. The research firm employed several different banding methods in unitizing four, five and six bag units, which included high strength plastic bands, fiber bands, heat shrinkable plastic bands and continuous multi-bag units. A continuous bag unitizing method showed more promise for reducing costs than the other methods studied. Potential savings from the continuous bag method over the present method of unitizing the consumer-size bags by putting them in multi-wall master bags and fiber-board cartons were 50 cents to \$1.00 per hundred pounds.

RPA 906 - CULTURE AND PROTECTION OF ORNAMENTALS AND TURF

Flower Transport

Work was continued on the evaluation of possible economies and advantages of cutting, handling, and air shipment of carnations in the bud instead of open flower stage. Time studies were made at greenhouses in Denver, Colorado, area to determine the average cost for cutting, movement to grading room, grading, and bunching of flowers cut in the open stage compared to flowers cut

in the bud stage. It was found that all of these operations could be performed faster with buds than with open flowers. Also, more buds than open flowers could be put in a carrying saddle, thus reducing the number of trips and cost for movement from the bench to the grading room.

Buds are more compact and take up less space than a like quantity of open flowers. Experiments show that about three times as many buds as open flowers can be packed in a carton. Therefore, a bud distribution system would require only about one-third as many cartons as the present system. Also, it was found that the packed weight of bud carnations is about 33 percent less than for an equal number of open flowers, so density was only doubled.

Based upon experiments thus far, it is estimated that savings in transport and handling costs of carnations shipped by air out of Colorado and California, if flowers were shipped in the bud instead of open stage, would be over \$1 million a year. In F.Y. 1969, it is intended to make some commercial shipments to explore further the feasibility of a bud distribution system.

RPA 601 - EXPANSION OF FOREIGN MARKETS FOR U. S. PRODUCTS

A. Improved Transport Techniques for Overseas Shipments.

1. Fresh Fruits and Vegetables. Four test container van loads, two each of fresh radishes and celery, were made from Florida to Europe. The two loads of radishes were shipped in waxed fiberboard boxes. One of the radish shipments was loaded using the conventional, wood-stripped stacking pattern, and the other using a new air-flow pattern developed during the year. The new pattern provided adequate air circulation around each box and eliminated the use of wooden strips between the layers of boxes, saving the shipper approximately \$25.00 per load compared to the conventional loading method. While, as in previous years, no radishes were shipped to Europe in 1967, there were 126 40-foot long refrigerated van container loads shipped from the U. S. in 1968. The 1968 volume is partly attributable to this research which helped to get the radishes to overseas markets in better condition.

The two van container loads of celery were sent to the U. S. Army at Kaiserslautern, Germany. Both loads were handled in the conventional manner with one ton of top ice placed on the top layer of cargo in the vans. A garden soaker hose was installed in one load. After the top ice melted, water was added for five minutes each day to determine if any benefits could be gained by adding moisture to shipments of leafy vegetables during transport. Because of the limited number of tests made, most of the results were inconclusive. Additional data were gathered on transport time, damage, refrigeration, insurance, documentation and handling costs and labor, and capital inputs. A research report on the shippers' cost for overseas shipments of fresh fruits and vegetables was written during the year.

2. Dried Beans. At the request of the Michigan Bean Commission, the unloading of 6,000 tons of dried Michigan Navy Beans from three different ships at Liverpool, England was observed. The beans were shipped in 100-pound burlap bags. Data were obtained on the type and extent of damage which occurred during unloading and related transport and handling. In the unloading of all three ships many beans were lost through spillage when the bags were ruptured or torn during handling from the ship's hold to the pier. Also, in one 400,000-pound shipment, 5,000 pounds were lost when they were damaged by water in the hold of the ship. The data gathered in this work will be used to plan further research to find ways to reduce costs and losses in shipping dried beans to overseas markets.

Publications - USDA and Cooperative Program

Transport Techniques

- Clayton, J. E., September 1967. Research to Develop Optimum Transportation Techniques for Perishable Products. *Transporti Industriali* - Italy.
- Clayton, J. E., October 1967. Containerization in Transporting Agricultural Perishables. A paper presented at the Conference on Containerization of the First International Container Show, Genoa, Italy.
- Clayton, J. E., October 1967. Containerization--A New Approach to Transportation of Agricultural Products. ARS Radio Service 'Agri Tape', Coverage 550 stations.
- Clayton, J. E., October 1967. New Developments in Transporting Products. Proceedings of the Sixteenth Annual Meeting of the Agricultural Research Institute, National Academy of Sciences, National Academy of Engineering, Washington, D.C.
- Clayton, J. E., 1968 Yearbook. Piggyback-Containerization and Fresh Fruits and Vegetables. United Fresh Fruit and Vegetable Association.
- Clayton, J. E., Winter 1967. Approaches, Opportunities, and Transport Job Ahead. *Transportation Journal*.
- Clayton, J. E., February 1968. Pace Quickens for Intermodal Perishable Moves. *Container News*.
- Chapogas, P. G., March 1968. Expanding Exports Through Better Physical Distribution. A paper presented at the International Conference on Handling Perishable Agricultural Commodities, Purdue University, Lafayette, Indiana.
- Clayton, J. E., March 1968. Better Food Transport Through Bigger Handling Units. A paper for the First Inter-American Port Seminar, Bogota, Columbia.
- Hinds, R. H., Jr., April 1968. Research Accomplishments and Needs to Improve the Overseas Transportation of Fruits, Vegetables, and Other Agricultural Products. Testimony given at a hearing of the Senate Committee on Small Business, Miami, Fla.
- Hinds, R. H., Jr., May 1968. Produce Transportation Problems and Equipment. A paper presented to the Super Market Institute Convention, Cleveland, Ohio.

COOPERATIVE MARKETING

Farmer Cooperative Service

USDA and Cooperative Program

Location of Intramural Work	: Scientist Man-Years F.Y. 1968		
	: Research Problem Area:		
	: 509	: 510	: Total
Washington, D. C.	: 2.6	: 2.5	: 5.1
Total	: 2.6	: 2.5	: 5.1

Intramural program is not supplemented by extramural support in these areas.

Problems and Objectives

Cooperatives have become broader in scope and diversified in activities. No longer do most of them handle only one commodity or supply one service. Problems inherent in cooperative growth and diversification are organization, financing, and management. Companion problems include searching out new types of cooperatives and new services to meet the changing needs of rural America, improving cooperative structures so as to increase efficiency and inject a higher level of competition into the marketing system, and improving the economic power of farmers through cooperatives as a means of insuring equitable terms of sale for individual farmers.

Major objectives of this cooperative research are to develop and evaluate alternative ways to:

Achieve more efficient organizational and financial structures for more effective diversified operations.

Insure more effective member participation and control.

Improve effectiveness and identify opportunities for providing additional marketing functions.

Add, modify, or develop different service-type activities and identify product innovations that will help improve effectiveness.

Achieve for farmers, through their cooperatives, economic strength in bringing about terms of trade more favorable to them than those prevailing or that would prevail otherwise.

Progress - USDA and Cooperative Program

RPA 509 - MARKETING FIRM AND SYSTEM EFFICIENCY

A. Cooperative Sales, Services, Distribution, and Pricing Practices

1. Citrus. A study was initiated to determine whether trends exist in selected specification requirements of retail and wholesale buyers and the extent these trends apply to all specifications and kinds of citrus fruit. Fresh shipments from Florida Interior area for the 1958-59, 1961-62 and 1966-67 seasons were evaluated. Preliminary findings indicate:

No significant, consistent change occurred in size of lot, number of lots, fruit sizes, varieties, and types of containers in truckloads shipped to retail and wholesale buyers.

Truck shipments to retailers contained fewer and larger lots than shipments to wholesale buyers.

Truck shipments to retailers contained fewer sizes of fruit per load than shipments to wholesalers.

Shipments to retail buyers contained fewer sizes but about the same number of varieties and types of containers per load than shipments to wholesalers.

2. Containers - fresh fruits and vegetables. A study on procuring containers for fresh fruits and vegetables on a cooperative basis showed that savings of about 10 percent, or \$3 million a year, appear possible if half the cooperatives would consolidate their purchases.

Containers and other packaging supply costs were 43 percent to total packing costs for fruit and 39 percent for vegetables. Such costs were 10.5 percent of the sales value of the fresh products.

Savings up to 10 percent may be realized from volume discounts, brokerage allowances, or negotiated prices for consolidated purchases. Five percent might be saved in fabricating and printing paperboard containers, but a more important advantage may be the assurance of a supply of high-quality containers. Savings of 10 to 14 percent may be available by producing burlap and paper bags; this was the experience of the one cooperative that produced these items in this country.

Most opportunities exist in cooperative purchasing on a brokerage basis. This can be undertaken by groups of small cooperatives with small staffs, and little capital.

3. Containers - processed fruits and vegetables. A related study was completed on the current status and potential for cooperatives to purchase or manufacture containers for processed fruits and vegetables. The study, covering 76 cooperative packers or about 75 percent of all such U.S. organizations, showed that if half the processing cooperatives pooled their orders for containers, they could save as much as 7 percent of container costs, or some \$6 million a year. Even greater savings appear possible by manufacturing metal cans, if enough cooperatives joined together to insure adequate volume. And fabricating and printing cardboard containers for shipping canned goods could save cooperatives 5 to 10 percent of present cost for these items.

Metal cans accounted for 68 percent of total container expenditures; corrugated cardboard cases (including cannery cases), 19 percent; glass containers, 7 percent; and other types, 6 percent.

Cooperatives bought 92 percent of their containers directly from manufacturers.

Various forms of quantity and cash discounts, brokerage allowances, and warehouse allowances were available to half the cooperatives reporting; 5 percent was the most common rate for quantity discount.

Container costs were 36 percent of total processing costs and 22 percent of the sales value of the processed products. Over 100 cooperative processors buy about \$160 million worth of containers and other packaging supplies each year.

4. Completed studies. A study appraising the trends and current status of fruit and vegetable marketing, processing, and bargaining cooperatives was completed. It included co-ops that sell their products on the fresh market or to processors, process these products, or bargain. Those that sell to the fresh market or to processors declined 30 percent between 1952 and 1964 and increased their sales 40 percent. Those that process declined 10 percent and increased their sales 175 percent. They packed 21 percent of all U.S. processed fruit and vegetables in 1964. Cooperatives that bargain grew slowly and the value of the products bargained for was valued at only one-fourth the value of the sales of either the co-ops that sell or process.

A study with the University of Tennessee was completed to determine the potential for statewide marketing of vegetables cooperatively. Findings indicate a need for a cooperative marketing association as vegetable growers' attitudes are favorable and sufficient volume is available.

RPA 510 - FARMER BARGAINING POWER

A. Fruits and Vegetables

Findings on coordinated marketing programs of selected fruit and vegetable cooperatives indicate that grower organizations involved in developing an integrated production-marketing system should:

Give the sales manager final authority for all decisions.

Establish and adhere to a uniform quality control program from the farm level to the finished product.

Strive for a program which includes a combination of association and buyer labels.

Consider cooperatively owning trucks for shipping produce to nearby markets.

Appraise members' interest in and possible support of a coordinated program to purchase production and marketing supplies.

Develop a centralized accounting system and supply members with periodic statements.

Have regular membership meetings and issue a periodical newsletter to assure better understanding between members and management.

A study to determine the potential of fruit and vegetable cooperatives on the Coastal Plains of North Carolina continues under a cooperative agreement with the North Carolina Agricultural and Technical State University.

B. Potatoes

Analysis of the role of cooperatives in the market structure of the Idaho potato industry was completed. Findings indicate that a cooperative potato marketing enterprise handled 11 percent of the production of Eastern Idaho in 1964, exerting an important influence on competing marketing firms. Grower-members received a higher return per hundredweight than the average price paid growers in Idaho.

Need continues for expanding the role of cooperative Idaho potato marketing to further insure growers' returns through improved services and greater bargaining power.

Similar analyses of cooperatives in Maine, Colorado and Florida are underway.

A related study to determine changes in the market organization and practices for potatoes produced in the Hastings area of Florida continues under contract by the University of Florida.

Publications - USDA and Cooperative Program

- Mather, J. W. 1967. Cooperative Procurement of Containers in Fruit and Vegetable Processing. FCS General Report 146.
- Mather, J. W. 1968. Container Procurement by Cooperative Fresh Fruit and Vegetable Packers. FCS Research Report 3.
- Meyer, C. H. 1968. Cooperatives in the Fruit and Vegetable Industry. FCS Service Report 93.
- Meyer, C. H. 1967. Improving Fruit and Vegetable Co-op Marketing. News for Farmer Cooperatives (Dec.).

ECONOMICS OF MARKETING

Marketing Economics Division, ERS

USDA and Cooperative Program

Location of Intramural Work	: Scientist Man-Years F.Y. 1968				
	: Research Problem Area :				
	: 503	: 507	: 508	: 509	: Total
Washington, D. C.	: 1.6	: 3.9	: 2.6	: 2.1	: 10.2
Florida	: 1.0	:	:	:	: 1.0
Total	: 2.6	: 3.9	: 2.6	: 2.1	: 11.2

Intramural program is supplemented by extramural support represented by 0.7 SMY at State Agricultural Experiment Stations.

Problem and Objectives

Constant changes in new technology and innovations are occurring in the physical processes of marketing agricultural commodities. These changes lead to reduced marketing costs with subsequent impacts on incomes to farmers, the competitive position of input and output marketing firms, and prices to consumers. The role of economic research is to provide more precise measures of these impacts and to analyze their effects on the performance of the marketing system.

Competitive relationships in agriculture change constantly with the development of new technology, shifts in costs and consumer tastes, and organizational changes in the production, marketing, and farm supply sectors. Information on the nature, extent, and ramifications of these changes provide a firmer basis for public policy and private investment decisions.

New agricultural products and processes or changes in existing product forms continue to be developed. Determination of the market potential for these new or improved products and processes is essential to management, both private and public, in making decisions relating whether or not to invest funds in various developmental aspects and for guidance in further research programs. Promotion also is a major element in the development of domestic markets for agricultural products. Agricultural commodity groups are spending over \$100 million annually to strengthen the demand for their products. Economic evaluation of such efforts are necessary so that the funds are used with maximum effectiveness by these groups and by new groups going into commodity promotion.

More than \$100 billion of consumer expenditures for agricultural products go for marketing, processing, and transportation services. The potential returns to improve efficiency are large but the adjustments within individual sectors must be coordinated with other sectors of the system to optimize results. In addition, improved measures of the performance of the marketing system and its subsectors are vital if these potential savings are to be realized.

Major objectives of this research are to:

1. Measure farm-to-retail price spreads and their components.
2. Determine alternative methods that result in increased efficiency.
3. Analyze the optimum size, number, type, and location of marketing facilities.
4. Develop market system specifications required to provide efficient services at minimum cost.

5. Determine and analyze major factors affecting locational advantages of industries engaged in the marketing, processing, and distribution of agricultural products.
6. Estimate equilibrium conditions with respect to market structure, plant and industry location, product flows and prices, cost efficiencies, and resource allocation.
7. Measure the impact that changes in major locational factors and Government programs have on regional competition and resource allocation.
8. Determine market potential for new or improved products and processes.
9. Measure the impact of new product developments or changes in existing products on consumption, marketing costs, and farmers' returns.
10. Evaluate alternative advertising and promotional methods.
11. Evaluate role of promotion and advertising in the development of markets for farm products.
12. Develop new measures of market performance.
13. Evaluate changing trends in marketing practices, utilization, and distribution patterns upon costs and efficiency of the individual firm and the marketing system as a whole.
14. Analyze costs and efficiencies of alternative agricultural product marketing and manufacturing systems.

Progress - USDA and Cooperative Program

RPA 503 - PHYSICAL AND ECONOMIC EFFICIENCY IN MARKETING FRUITS AND VEGETABLES

A. Marketing Margins

Price collections were continued on 31 fresh fruit and vegetable items, 19 canned fruits and vegetables, 12 frozen items and 1 dried commodity. Price spreads were calculated from the basic price data. These data show for example that in 1967 the total U.S. apple crop was only slightly smaller than in 1966. However, the 1967 Washington Red Delicious Apple Crop was about one-fifth smaller than the 1966 crop. The average retail price per

pound for Washington Red Delicious Apples in Chicago and New York City was 27.3 cents for the 1967-68 marketing season; 1.8 cents per pound more than in 1966-67. The retail value of a 42 pound carton of apples averaged \$11.00 in 1967-68 as compared to \$10.25 the previous season. The amount received by the grower-packer increased from \$4.46 a carton in 1966-67 to \$5.71 in 1967-68. The grower-packer returns in 1967-68 represented 52 percent of the retail price. The retail margin increased from \$3.69 a carton to \$4.23, while the transportation-auction margin dropped from \$2.05 to \$1.06.

The 1967 sweetpotato crop was about equal to the small 1966 crop. However, prices in the 1967-68 marketing season were somewhat higher than in 1966-67. The average retail price per pound for sweetpotatoes in New York and Chicago increased from 16.2 cents in 1966-67 to 18.4 cents in 1967-68. The average retail value of a 47-pound crate of sweetpotatoes in these cities was \$7.79 in 1967-68. This was 95 cents higher than in the preceding season. The returns to the grower-packer were \$4.29 in 1967-68, an increase of 26 cents. The remainder of the increase went for a larger retail margin.

B. Fruit and Vegetable Processing

Vegetable canning and freezing plants in the Southern States were surveyed to determine vegetable processing capacity and utilization. Plant data were classified by geographic area, sizes, and types. The processing plants included 134 canning plants; 18 freezing plants and 2 canner-freezer combination plants. Texas had the largest number of plants, 29; Tennessee had almost 40 percent of the freezing plants. The analysis of plant capacity under usual conditions established the capacity of vegetable canning at 58 million cases. Freezing capacity was approximately 256 million pounds of vegetables. Canning plants utilized only 57 percent of their vegetable processing capacity; freezers used 74 percent of their capacity. About 390,000 tons of vegetable raw products could have been processed by using surplus capacity; 38 percent of this tonnage was in Louisiana and Texas.

RPA 508 - DEVELOPMENT OF DOMESTIC MARKETS FOR FARM PRODUCTS

Floral and Nursery Products

Approximately one-third of the adult population made one or more purchases of floral or nursery products during 1966-67. Slightly more than half of these purchases were made at retail florist establishments. One-fifth of the purchases were for funerals or memorials. More than 50 percent of the purchases for funerals or memorials were for arrangements of cut flowers, nearly 15 percent were unarranged cut flowers and another 15 percent were for artificial products. Nearly 80 percent of the purchases for birthdays and anniversaries were cut flowers.

Purchases of floral and nursery products tend to be more frequent in metropolitan than in non-metropolitan areas. Women are more likely than men to make purchases throughout the year. Purchases are more frequent among whites than nonwhites. Purchases, in general, tend to increase with age, reaching a peak among persons 40 to 49 years old. The higher the educational and income levels, the greater the purchasing activity.

RPA 509 - MARKETING FIRM AND SYSTEM EFFICIENCY

Ornamentals

More than 1300 woody ornamental nurseries were interviewed in 11 Southern States. Approximately 55 percent of these nurseries were established after 1950; only 13 percent were in business prior to 1930. The average value of sales for all firms in the region was \$39,500; the range was from \$20,400 for proprietorships to \$110,100 for corporations. Broadleaf evergreens are the most important product produced. In 1965-66 more than 50 million broadleaf evergreens were sold by the nurseries interviewed, compared with 42 million deciduous shrubs, 23 million narrow leaf evergreens and 28 million ornamental trees. The estimated value of production of the 1300 nurseries in 11 States was more than \$52 million. The leading State was Florida (\$17 million), followed by Virginia (\$7 million), Texas (\$6 million), Tennessee (\$5 million), and Alabama (\$5 million).

Publications - USDA and Cooperative Program

RPA 503 - PHYSICAL AND ECONOMIC EFFICIENCY IN MARKETING FRUITS AND VEGETABLES

Pearson, James L., April 1968. Utilization of the South's Vegetable Processing Capacity. AER-EC-68-5, 48 pp.

RPA 507 - COMPETITIVE INTERRELATIONSHIPS IN AGRICULTURE

Hanes, John K., July 1967. Structure of Potato Marketing in the Red River Valley. Proceedings, Seventeenth National Potato Utilization Conference ARS, USDA, pp. 38-43.

RPA 508 - DEVELOPMENT OF DOMESTIC MARKETS FOR FARM PRODUCTS

Havas, Nick, April 1967. A Graphic View of the Retail Florist Industry. MRR-788, 48 pp.

CONSUMER ATTITUDES AND PREFERENCES

Special Surveys Branch, SRS

RPA 508 - DEVELOPMENT OF DOMESTIC MARKETS FOR FARM PRODUCTS

USDA and Cooperative Program

		:	:	Scientist Man-Years
Location of Intramural Work	Commodity	:	:	F.Y. 1968
Washington, D.C.	Fruits	:	:	1.5
Washington, D.C.	Vegetables	:	:	0.2
Total		:	:	1.7

Intramural program is supplemented by extramural support representing 1.1 SMYs at private market research firms.

Problems and Objectives

Domestic consumption of agricultural commodities depends on the behavior of some 200 million consumers. But, in our complex marketing economy, it has become almost impossible for consumers to discuss their opinions, preferences, and complaints with producers and marketers. Knowledge of consumer reactions to agricultural products is becoming increasingly important because we are in a period of rapid change: There is a growing challenge to farm products and farm income from a wide variety of competitive products of nonagricultural origin; there is a proliferation of mixtures, forms, processes, blends, and other innovations affecting farm products; there is an increasing awareness of the adverse effects incorrect decisions made as a result of inadequate information on the consumer's viewpoint can have on USDA functions as well as farm income.

Major objectives of this market development research are:

1. Establishment of a line of communication from consumers back to those concerned with production, processing, and marketing farm products.
2. Identification of areas on which technical research should focus to provide farm products with characteristics that will increase consumer acceptance.
3. Evaluation of consumers' reactions to specific product variations under controlled laboratory conditions.
4. Assessment of consumers' knowledge and opinions concerning Department functions such as educational programs, setting grades and standards, and inspection of farm products.

Progress - USDA and Cooperative Program

A. Fruits

1. Nationwide citrus study - Information has been gathered from a nationwide sample of homemakers on their experiences, beliefs, attitudes, and criticisms of citrus and citrus products, as well as the impact of synthetic products on their attitudes toward natural fruit products. Small-scale exploratory activity was conducted prior to the main survey to assure that major issues related to attitudes toward the purchase and use of citrus that might otherwise be overlooked were covered in the full-scale survey, or at least identified for consideration. The citrus fruits asked about in the questionnaire are oranges, grapefruit, and lemons. Juices from these fruits are also covered. The field interviewing was concluded in June 1968, and the coding phase is now in progress.

2. Instant grapefruit and orange juices - Preliminary results have been released on a study to evaluate consumer acceptance of foam-mat dried grapefruit juice crystals, which was financed in part by the Florida Citrus Commission and the Fruit and Vegetable Laboratory of the Agricultural Research Service, which developed the product. The survey indicated that the concept of this new product was well received, but that the chances of successfully marketing the grapefruit juice crystals would be enhanced if the flavor were improved and if the crystals could be made to dissolve a little more easily. A more detailed report on these results is being prepared for publication.

Experiments conducted recently on storage stability of orange juice crystals suggest that the Fruit and Vegetable Products Laboratory may have solved the shelf-life problem for this product--there was no significant difference between the mean preference scores for samples stored at 85°F for 6 months and samples which had not been stored at all.

Another series of experiments on instant orange juice showed that there was no significant difference in subject preference ratings between juices sweetened with calcium cyclamate or sucrose. However, both of these sweetened juices were preferred to the unsweetened juice. However, further sensory evaluation work on the instant orange juice in comparison with two synthetic orange flavored drink powders currently on the market indicated that the orange crystals would also be more appealing to consumers if the flavor were improved, since it did not compare favorably with the synthetics.

In a later study conducted on samples of orange juice reconstituted from frozen concentrate, there was again no significant difference in preference ratings between the calcium cyclamate and sucrose sweetened juices. This study was conducted at the request of the Florida Citrus Commission, which is working with industry to develop improved orange juice products. Ten different frozen concentrates varying in Brix/acid ratio and the type and amount of sweetener added--sucrose or calcium cyclamate--were selected. These juices were rated to determine which of the artificially sweetened products would have the greatest flavor appeal to consumers and whether it would compare favorably with the sugared and naturally sweet juices at the same Brix/acid ratio. The results of this test provided a basis for selecting the product to be used for a market test by the Commission on artificially sweetened orange juice.

The same industry groups have embarked on a program of improving canned single strength orange juice which they hope will make this product more appealing to consumers. A series of tests were conducted to investigate people's reactions to variations in factors such as brix/acid ratio, storage conditions and the particular variety or combinations of varieties of oranges from which the canned juices were manufactured. The most striking finding of the study was that almost invariably the higher the

brix/acid ratio, the higher the preference rating. It was also found that canned single strength orange juice stored over a long period of time in a cold location (40°F) was significantly preferred to juice from the same pack which had been stored under unfavorable temperature conditions such as might be found in many warehouses (80°F).

3. Peel oil levels in orange juice - A contract, financed in large part by ARS, has been signed with a private market research firm to investigate consumer acceptance of frozen concentrated orange juice at different peel oil levels to obtain insights into the effect which variations in peel oil levels have on preferences. A related study will be conducted in the SRS Sensory Evaluation Laboratory to augment the research conducted by the contractor.

B. Vegetables

1. Potatoes, rice and wheat - The final report is being prepared for publication for a nationwide study among homemakers on their use of and opinions about selected potato, rice, and wheat products. Almost all of the homemakers interviewed reported that they had used white bread and some form of white potatoes and rice during the year preceding the interview. In general, the homemakers felt that fresh white potatoes, regular uncooked rice, and bread were high in food value, fattening, and low cost per serving.

Among respondents who said they had used some processed potato or rice products, the feeling for the most part was that these products were higher in cost per serving than if prepared "from scratch" by the homemakers, but they were used primarily because they were easier or quicker to prepare.

Publications - USDA and Cooperative Program

None

SUPPLY, DEMAND AND PRICE ANALYSES
(RPA 506)

Economic and Statistical Analysis Division, ERS

USDA and Cooperative Program

Location of Intramural Work :		Commodity :	Scientist Man-Years F.Y. 1968
Washington, D. C.	:	Fruits :	2.0
Washington, D. C.	:	Vegetables :	1.0
Total :			3.0

Intramural program is not supplemented by extramural support.

Problem and Objectives

Farmers, processors, distributors, policy officials, and others need continuing economic intelligence regarding supply, demand, and price prospects to aid them in making sound production and marketing decisions to help assure adequate, well-balanced supplies of food and fiber. To insure that the situation and outlook work is as accurate and precise as possible, continuing research is needed on supply response to price, effect of supplies on price, and the effect of changing demand on prices and income.

Major objectives of the research are to:

1. Provide research needed for strengthening situation and outlook work.
2. Improve forecasts of future supply and demand prospects.
3. Appraise market situations and prospects to aid decision makers in making sound and profitable decisions.
4. Appraise current and proposed programs to aid officials in formulating agricultural programs and policies.
5. Develop and improve basic statistics for use in statistical and economic analysis.

Progress - USDA and Cooperative Programs

A. Fruits

A comprehensive analysis of production, utilization and prices of Florida oranges was begun in 1968, with the objective of projecting these factors through 1980. Substantial progress has been made on projecting planted acreage through 1975 and bearing acreage, yield per acre, and production through 1980. Regression analysis has proved suitable for evaluating the relationships which determine the utilization mix among final products. However, no means have yet been found for projecting some of the variables on which utilization projections depend. Price estimation based on demand function analysis has been explored through regression techniques; but this approach has not proved completely satisfactory and further analysis of demand functions is necessary.

More comprehensive presentations were made in the Fruit Situation of data and analyses relating to processed citrus and noncitrus fruits. Emphasis was given to fresh fruit marketing, geographic distribution of fruit and nut production, and per capita consumption of fruit and tree nuts.

Expansion and refinement of historical data relating to processed citrus fruits and frozen noncitrus fruits has been started to upgrade capacity for current analyses and provide data for in-depth study of several commodity markets.

B. Vegetables

Long term prospects for production and utilization of vegetables and potatoes were given attention. Projections to 1980 suggest little change in per capita use of these foods, but total consumption will rise substantially because of population increases. The shift from fresh to processed use likely will continue. A contribution was made to a project sponsored by the Organization for Economic Cooperation and Development to analyze production and market prospects for horticultural crops important in world trade. For tomatoes, it was concluded that a relatively strong fresh market situation would continue for some years, particularly in Europe. However, because of increased productive capacity, supplies of processed tomatoes will be relatively large, resulting in a depressed market. Studies are in process for several other leading vegetables.

More than usual efforts were required to revise consumption data for vegetables, potatoes, and sweetpotatoes because of changes in basic production data due to census revisions, and to changes in factors relating to equivalent fresh and processed weights. The overall effect of the revisions was a slight reduction in the rate of shift from fresh to processed. Still, during the last few years, canned and frozen vegetables accounted for more than half of total consumption.

Publications - USDA and Cooperative Program

Fruits

Brader, C. R. Fruit Situation. Published 4 times a year. ERS, USDA.
Washington, D.C.

Vegetables

Kuryloski, D. S. Vegetable Situation, published quarterly. ERS, USDA.
Washington, D.C.

